

BASIC: Building, Assessing and Standardising Information on the Atlantic Coasts

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Abstract

European projects such as the Interreg funded BASIC project (Building, Assessing and Standardising Information on Atlantic Coasts) (Cummins *et al.*; 2001) show the potential of utilizing a combination of tools with Geographic Information Systems (GIS), such as hydrodynamic models and the Internet to communicate scientific results at a range of levels and to a variety of audiences, including scientists, managers and the general public. The BASIC project was a scoping study, aimed to pave the way for future common methodologies and tools dealing with Arc Atlantic water quality and the assessment of its impact on coastal activities.

This paper outlines the New Information and Communication Technologies (NICT) that were utilised to optimise the decision making process in the event of pollution from bacteriological contamination in shellfish. BASIC addressed interoperability issues by developing mechanisms to facilitate the transfer of data from models to GIS. A GIS/model interface was written for this purpose. Three study sites were identified: Bantry Bay, Ireland; Golfe du Morbihan, France; and the Fal Estuary, UK. General and topic-related data (sewage outfalls, shellfish culture beds, bathing water data etc.) were collated from each study area and organised into a database with a common structure and harmonised metadata. This approach highlighted a lack of common minimum standards in Geographic Information (GI) data between the three countries. The need for wider adoption of the core GI dataset concept with increased efforts at harmonisation of attributes was recognised.

Access to information was a fundamental issue addressed within BASIC. A multimedia monograph focusing on the Golfe du Morbihan was developed to demonstrate dissemination of data and information to a wide audience. Customised GIS and expert GIS systems were also demonstrated as alternative methods for dissemination.

Background

This paper addresses the need for integrated spatial data exchange systems as identified in the INTERREG funded BASIC project (Building, Assessing, Standardising Information on Atlantic Coasts). The BASIC project was a scoping study to establish a common approach to examining the impact of Atlantic Arc water quality and dynamics on coastal activity and sensitive marine areas. The project was conducted between the Coastal Resources Centre, University College Cork; Ifremer, France; and CEFAS, UK. It ran for three years and was completed in December

2001. The driving force for such research stems from increased anthropogenic pressure on foreshore and near-shore environments, resulting in quantitative and qualitative modifications to the coastal zones, which may have significant economic and ecological impacts. The EU Strategy on Coastal Zone Management (European Commission, 2000) identifies the need to improve the availability of data and information on coastal zone issues to decision makers and resource managers to achieve sustainable development in the coastal zone. In order to achieve this objective, the following conditions need to be considered:

- The need for baseline mapping of multi-source data.
- The need for information exchange within countries, and between different countries due to the trans-boundary nature of the marine environment.
- The need for a common display of geo-information related to water quality and its impact in the coastal zone.
- The need for transparency in the communication and dissemination of data and information to decision-makers.
- The need for information to improve public understanding of the marine and coastal environment. This includes dissemination of relevant information to the European Environment Agency (EEA) as well national environmental authorities.
- The need to incorporate observational data with outputs from hydrodynamic model simulations.

New Information and Communication Technologies (NICT), such as the Internet, GIS and hydrodynamic models, can be used to address these conditions and to provide assistance at a local level in water resources management. A major challenge is to achieve a standardised approach for the comparison of results and to communicate potential solutions to end-users. This scoping study examined the issues related to these challenges and developed tools to facilitate data integration and decision making in the marine and coastal area.

Objectives of the Study

The primary objectives of the study were:

- To examine the feasibility of establishing common practise in water quality modelling and in establishing indicators resulting from model outputs.
- To examine the feasibility of establishing common display of geo-information related to water quality and its impact in the coastal zone.
- To facilitate information exchange between Atlantic Arc coasts, specifically geared towards end users and stakeholders.
- To support and improve the determination of threshold values in European coastal waters.

Methods

Three study sites were selected from each of the partner countries: Bantry Bay (south west Ireland), the Fal Estuary (south west England) and the Golfe du Morbihan (north west France). Criteria for site selection included the availability of data on hydrodynamic regimes and water quality parameters. The three sites have distinctive environmental characteristics, ranging from

the relatively deep water and exposed environment of Bantry Bay to the relatively enclosed but tidally energetic Golfe du Morbihan. The Fal Estuary can be considered intermediate in terms of tidal energy and exposure. Unlike Bantry Bay, the Fal Estuary and the Golfe du Morbihan both have extensive drying tidal flats.

Coastal activities with a potential impact on water quality were identified in each of the study sites (e.g. waste disposal, bacterial effects on shellfish, toxic plankton blooms etc.). The impact of bacteriological contamination (specifically *Escherichia coli* [*E. coli*]) on shellfish was identified as a common threat in each of the study areas. Closure of such fisheries due to bacteriological contamination may have a significant effect on local economies. In addition, the regulation of bacterial contamination, and the decay rate (T90), is well established and documented. For these reasons, this issue became the main focus for the application of the work. Shellfish harvesting is controlled under the 'Shellfish Hygiene' Directive (Council Directive 91/492 laying down the health conditions for the production and the placing on the market of live bivalve molluscs) thereby providing a common legislative framework.

In order to demonstrate data management applied to the impact of bacteriological contamination of shellfish waters, a number of steps were taken to develop the methodology. They were: Model review; Model development; GIS data needs and availability; Interface between model output and GIS; Metadata; and Dissemination.

Model review:

A review of model availability through a questionnaire survey showed that a range of models could be applied to each of the study areas described above. For example, Bantry Bay is covered by the Irish Coastal Hydrodynamic Model (4km resolution). Outputs are tidal currents elevations and constituents. Models such as the Princeton Oceanographic Model (POM), also with a 4km resolution, could be applied to the Fal Estuary. The MARS 2D model, developed by Ifremer is a regional model extending from 70° N up to 65° N and 20° W to 15° E with a 5km step grid. A comprehensive comparison of model availability resulted in the selection of the MARS 2D model for project use, primarily because the model could be made freely available through Ifremer. The option to unite all partners' sites within a single MARS model domain, although technically feasible in the long term, was not feasible within this scoping project due to practical limitations, including time constraints and issues relating to availability and geodetic aspects of necessary input data.

Model development:

Following the selection of the MARS 2 D model and agreement to focus on the French study site, the next step was to develop a nested version of the MARS 2D numerical model for the Golfe du Morbihan. Model development was carried out at Ifremer. The mathematical model constructed under BASIC covers the entire Golfe du Morbihan, as well as a large part of the Bay of Quiberon. Resolution of the fine mesh model was 70m. Input data from 19 main sewage discharge points, in conjunction with bathymetric data and meteorological data were used. The model was run according to selected scenarios. The various simulations considered were designed to characterise the following effects:

- The influence of the tidal coefficient: simulations were made over a period of three weeks under real tidal conditions. This period enabled investigation of both spring tide and neap tide conditions. The tidal period chosen, both for winter and summer was that of November 2000.

- Seasonal influence: this was undertaken to investigate the effect of seasonal variation in discharge volume i.e. coliform flux.
- Wind influence: three types of weather conditions were selected, in accordance with wind statistics from the Talut meteorological station supplied by Météo France. The baseline wind condition was that of no wind. Two further dominant directions investigated were westerly and northeasterly winds, with a speed of 8 m/s for both.
- T90 influence: the two T90s chosen were 10h for summer and 24h for winter, which corresponds to in-situ experience.
- Impact of major malfunctioning of water treatment plants in periods of heavy rainfall: this malfunctioning was modelling by doubling the amounts of bacteria discharged over a 24 hour period, which is typical of what can occur during a summer storm. The objective was to investigate the impact of episodic events on coliform distribution, particularly in respect of existing patterns of zonation of waters for shellfish cultivation under the Shellfish Directive.

The above scenarios were investigated through a combined series of seven simulations (two seasons under three different conditions, plus one exceptional situation type). These results were validated through comparison of modelled coliform distribution patterns with existing zonation of shellfish farming waters according to European standards applied to the results, on the one hand, and the zoning made using the REMI monitoring network measurements, on the other.

GIS data needs and availability:

In order to further explore the issue of harmonisation and standardisation of geographic information, it was necessary to consider the overall structure and relationships between various classes of spatial data concerned. A conceptual model was produced as a mechanism to highlight the entity relationships (E-R) within the system. On this basis, a GIS was created for each of the study sites for the purpose of comparing and contrasting issues pertaining to data integration between all three. ArcView 3.2 was selected as the implementation software as it was common to all partners. Each GIS incorporated the following GI layers considered essential to the project:

Base Map

Coastline

Bathymetry

Toponymy

Administrative Boundaries

6 mile limit

Boundaries of responsible authorities

Topic-related layers

Mariculture areas

Natural Shellfish harvesting areas (Fal only)

Shellfish classifications

Contaminants

- Sewage discharges (point sources)
- Harbours/moorings
- Monitoring networks

Model output (Golfe du Morbihan only)

- Concentrations
- Current speed

Interface between model output and GIS:

The MARS 2D model output was produced in NETCDF (Network Common Data Form) format. At this point, a challenge to integrate data sources and to visualize results for coastal decision makers arises. Work was carried out on the development of an interface between the MARS hydrodynamic model and GIS. A stand-alone interface (ModelConv) developed at the Ifremer laboratory in Brest, facilitates the extraction of NETCDF to a standard ASCII format, which can be read into a GIS program (ArcView, Map Info, etc) as well as in spreadsheet software such as Excel. ModelConv was successfully used to incorporate model output into a GIS of the Golfe du Morbihan.

Metadata:

When determining which metadata standard to adopt for the BASIC project, the primary consideration was the scope of the project, coupled with the limited timeframe available for the study, which necessitated that any metadata system should be relatively easy to implement. Whilst the full metadata standards, such as ISO/TC211 or CEN287, are by necessity very comprehensive, they were overly detailed for the requirements within BASIC. Following a review of existing metadata guidelines, the best features of these guidelines were used to design a metadata database, which met the requirements of the project, whilst being sufficiently generic to be used for other purposes. The database was designed using Microsoft[®] Access 2000.

Dissemination:

A fundamental component of the BASIC project was to the exchange of data between the GIS and model developers and the potential end users. Table 1 shows a summary of the main characteristics of a multi tiered system of providing data and access to information.

Table 1. A three pronged approach to disseminating BASIC data and information using GIS and Internet applications

Application	Characterised by
Web based access	Platform independent Only “information” is conveyed (pre processed models synthesis) Access to GIS files (future developments)
Customised GIS (e.g. ArcView)	User channelled through specific interface Only “information” is conveyed Limited GIS capabilities (zoom, identify, pan etc.)
Fully functional GIS	Access to data itself (individual situations) Raster database necessary to allow queries Additional statistical capabilities to be developed GIS expertise required

As discussed, a fully functional GIS was developed for the three study areas incorporating specified thematic layers. Options for customisation were examined in relation to the Bantry Bay site, and the potential of a multi media web-mapping environment in the form of a regional monograph for the Golfe du Morbihan was considered.

Discussion

As this paper is primarily concerned with linkages in the context of dealing with spatial data, the results of the modelling component of the research are not presented in detail. A detailed review of the results can be found in Cummins *et al* (2001). Suffice to say that overall, the simulated distributions were found to match well with the shellfish hygiene zones classified under the Shellfish Directive in the Golfe Du Morbihan, as shown in Figures 1 and 2.

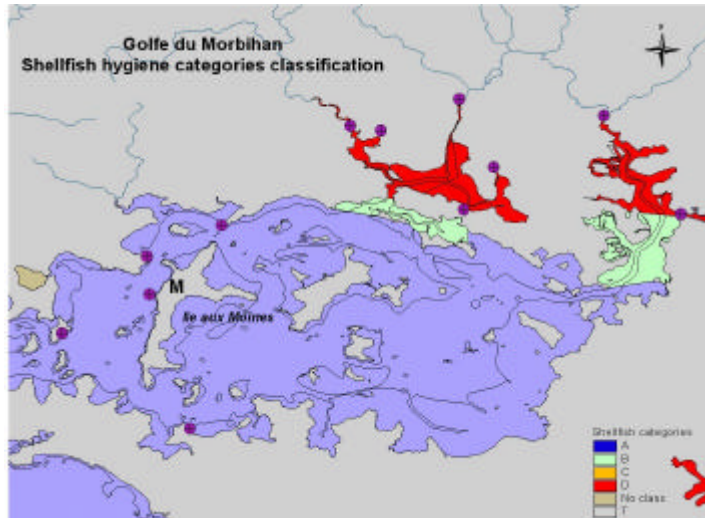


Figure 1. Screenshot showing hygiene categories for shellfish farming areas in the Golfe du Morbihan

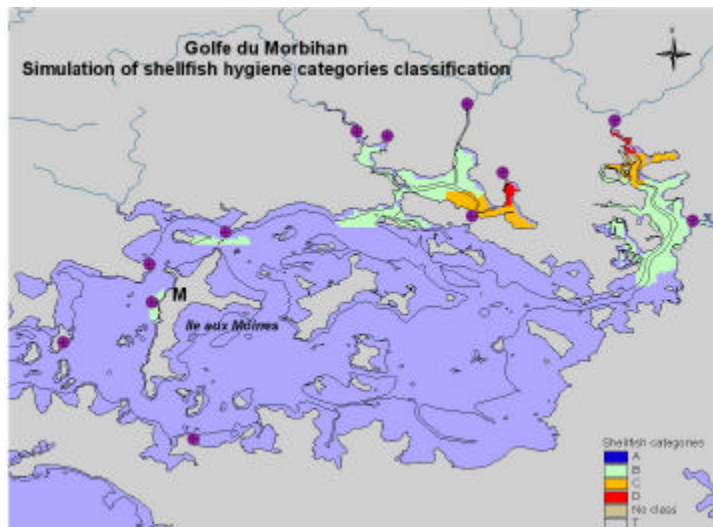


Figure 2. Screenshot showing numerical modelling simulation of hygiene categories for shellfish farming areas in the Golfe du Morbihan

In dealing with the geographic data layers, a hierarchy of increasing levels of complexity was identified, in which:

1. A **First Order** would comprise: *Base map*, *Administrative boundaries*, and *Topic related layers (now includes monitoring networks)*. These are considered to conform easily to established

metadata standards (metadata are relatively easily available). These data types are simple to deal with and need not be formally standardised for the BASIC principle/toolkit to operate.

2. A **Second Order** of data would comprise: *Contaminants (sources and amounts)*; which are characterised by:

- a) High temporal variability
- b) Complete lack of standardisation in approaches to data collection and expression
- c) And having a fundamental requirement for:
 - o A data management structure
 - o Agreed standards for expression of parameters e.g. fluxes (differences in monitoring techniques and ways to express results) in order to proceed in the basic principle/toolkit.

3. A **Third Order** of data would comprise: *Grids*; which are characterised by:

- a) Having high variability within a large number of parameters that characterise any one model run
- b) And having a fundamental requirement for:
 - o Logical continuity and consistency of nomenclature enabling trace-ability
 - o A specific data management structure in order to proceed in the basic principle/toolkit.

The metadata database, which was designed to capture very detailed information from the modelling and GIS domains, while being easy to use, did not prove to be sufficient for dealing with the large volume of raster files, generated by the model output. The model output's metadata is dependant on the way these raster files are managed (described above as the third order of data). The BASIC toolkit, including ModelConv, allows a user to work effectively with a given limited number of grids from a limited number of modelled scenarios. To be able to manage the integration of spatial data under operational loads involving an increased number of modelled situations, the process will have to be increasingly automated.

The incorporation of model output into a GIS environment facilitated the visualisation and manipulation of the data at another level. Initially, a customised GIS appeared to be an appropriate method for communicating information to the end user. However, it was realised that potential end users would have different levels of computer skills and requirements. For example, a GIS expert may wish to exploit the grid files (output from Modelconv) under a GIS; a non-experienced GIS user may wish to simply view the information that is provided by the BASIC GIS layers. As an alternative, web based access to information as a method of disseminating data and information to end-users has the advantage of being platform independent. The study concluded that a multi-tiered approach to dissemination can be useful, however, there is scope to further explore innovative ways to encourage multilateral stakeholder

participation in coastal decision making by tailoring products to cater for various groups or levels of end users.

Continued refinement of models such as MARS 2D (towards MARS 3D), interface development between the model and the GIS domain (ModelConv), and the mechanisms for data management (Conceptual models/Metadata systems) and dissemination (GIS/Internet platforms) will enhance the understanding and exchange of GI data at European, national and local levels. This was demonstrated at the local level in the case of the distribution of bacteriological contamination in the Golfe du Morbihan. The lessons learnt and the techniques developed in the BASIC project can be transferred to other scenarios to address water quality and to ultimately improve management of the coastal zone.

References

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