INTEGRATED MARINE DATA REPOSITORY FOR MACARONESIA -REDMIC-

Juan Antonio Bermejo[(1)] & Antonio Machado, Ph D[(1)]

Observatorio Ambiental Granadilla, Edf. Puerto Ciudad, oficina 1ºB, 38001 S/C de Tenerife, Spain
[(1)]e-mail: juanbermejo@oag-fundacion.org

ABSTRACT

The aim of the Integrated Marine Data Repository for Macaronesia (REDMIC) is to provide a permanent system of systematic storage, custody and service of marine data of the Canary Islands and, by extension, the Macaronesia Region. The repository is configured as an open system of integrated geographic information suitable for searching, viewing, downloading, and data analysis. The REDMIC is presented as a single database capable of covering all areas. Data, whatever their nature, bound by the activity that generates them, and these are grouped by type of activity, with total freedom to define them. Using a common data model (ArcMarine) allows developing analytical functionalities that access to any data whatever the activity it has generated. This achieve it will support the research community, interested citizens, marine user-groups, local planning and management authorities, as well as policy actions derived from the Habitat Directive, Water Quality Directive and Marine Strategy Directive. Covering the Macaronesian region in the NE-Atlantic, it aims to be integrated in the Marine Data Infrastructure of Europe, and supports the provisions of Directive 2007/2/EC INSPIRE. Moreover, as pilot-project we hope it becomes an attractive operational model that can be replicated in other marine regions (Pacific, Caribbean, etc.)

Keywords: *SDI, GIS, Marine, Coast, Data repository, Spain, Macaronesia, Canary Island, ArcMarine, Marine data*

1 INTRODUCTION

There is a growing demand for marine and coastal data, linked to increased use of resources and needs of predicting environmental change. Knowing better the marine environment is a challenge for the society of the XXI Century. Data obtained from the sea are expensive, and therefore, once taken, they should be used as much as possible. The development of new web techniques and standards allow reducing costs in accessing and sharing of geographic information. At present, marine data in Macaronesia region are poorly or even not structured at all in many cases. The situation is far behind that of terrestrial. Moreover, there is no general instrument, like OSPAR, that covers the Madeira and Canary Islands European waters. The opportunity of combining the new GIS technologies, the ArcMarine logic data model, and the institutional concept of the OAG based on collaborative action, is there, as well as the challenge. Conservation, sustainable use, or combating climate change without sound information is a fallacy. Thus, the REDMIC aims to support, from the very basis, the understanding, conservation and sustainable use of biodiversity and ecosystem services of the sea in this part of the NE Atlantic. Its need less to explain what synergy means.

2 OBJECTIVES

The REDMIC development is planned in three phases:

- Phase I. Design and set up of hardware and basic software.
- Phase II. Programming of functional modules and species distribution data entry.
- Phase III. Programming data deposit functionalities and start of massive data entry.

The specific objective now is to cover the second phase of the implementation of the complex structure of REDMIC. A low input-high output measure, as part of the REDMIC is already available.

Phase 1

During 2009 and 2011, the REDMIC was designed based on the knowledge gained by studying the current state of similar projects. The OAG hired a GIS technician and invested in hardware, software, and telecommunications. Contacts with different agencies were established, most bibliography from the Canaries was compiled, and a prototype of the web portal was opened (http://www.redmic.net). Bathymetry and data on some anthropic features have been incorporated to the database and publish.

Phase II

Actually, the specific objectives are the following:

1. Establish coordination protocols between the Canaries and Madeira in order to share and work simultaneously with REDMIC, and train technicians to run the different modules.
2. Develop the software to facilitate data handling (adding, editing, transfer, user – friendly interfaces, etc.)
3. Incorporate basic administrative data (protected areas, institutions, etc.) and feeding data for the Canary Islands and Madeira Archipelago as an continuous process.
4. Disseminate the goals, scope, and usefulness of REDMIC to promote its effective use.

Phase III

In the future, we will centre on the development of interactive software for external users (deposition of data, user-rights, etc.), massive feeding of all sorts of marine data (buoys, marine climate, bionomics, fisheries, etc.) extended to the Azores, and eventually, exporting the model to new partners in Europe or overseas regions. An important part of data feeding will be the existing detailed marine bionomic surveys of all the Canary Islands (done with different methodologies), that need to be standardized and pass quality control in order to habilitate a sound use of them and recover this valuable asset of marine information (almost dead, at present). Products such as the Marine Atlas of Madeira, Azores or the Canaries could be available only at this future phase.

3 ACTIVITIES

The REDMIC is conceived as a service in perpetuity provided by the OAG and based at its Data Centre in Santa Cruz de Tenerife. It can be operated from other localities (Funchal, in this case) and in the future it can be replicated elsewhere as a technology transfer.

Activities have been grouped as follows:

1. Coordination & training
2. Module development (interface to the database)
3. Data entry
4. Dissemination

3.1. COORDINATION & TRAINING

We need coordination in order to establish work patterns among both partners. This will involve links among project teams, and assisting to develop activity plans to ensure project outcomes are achieved. The Project Coordinator (based in Tenerife) will track project and provide advice to staff on appropriate issues which arise through day to day operations. This includes the consolidation and interactive revision of the conceptual model, logical design of the geodatabase, content of operational modules, and tests of consistency.

It is also necessary to train people responsible for data-feeding to understand the variety and characteristics of marine data, as well as handling the specialized data-entry modules. Training will take place at the Canaries and at a specialized centre in the Continent.

3.2. MODULE DEVELOPMENT (INTERFACE TO THE DATABASE)

The OAG has already made a significant effort acquiring hardware and standard software to sustain the Marine Data Repository. However, in order to run the Repository in an integrated manner according to the ArcMarine conceptual framework, there is a need of considerable programming, namely, the development of specific modules that allow user-friendly incorporation of data into the system, handling metadata (institutions, platforms, sensors, parameter descriptions, etc), quality assessment procedures, etc. The following is a summary of the modules to be developed:

Administrative module (business tables): This is a core module that includes the log-in facility (with users & roles) and links all data providing activities with supporting information. For instance:

- Activity: is used to record data pertaining to data collection activities. An Activity belongs to an Activity type and is undertaken on a Platform with a Measuring Device by an Organization, and has a begin and end date.
- Contact: A contact belongs to an Organization and has at least one role in relation to an Activity (field operator, analyst, coordinator, etc.). One kind of contacts are the user (with different possible roles)
- Organization: is used to record data in relation to an Organization. An Organization has roles in relation to an Activity (supervising, executing, calibrating, partner, etc).
- Platform: is used to hold Measuring Devices which record data pertaining to a platform (buoys, ships, etc). A platform belongs to an Organization that performs activities on it.

Data are incorporated within an Activity, but the way this is done depends on the kind of activity (Activity type), which imply different data types (measuring devices, parameters, etc).

Chorologic module (= species distribution): For recording species presence at specific locations, with variable precision (radius of 10 m, 200 m, 1 k, 5 km, etc.). Records are taken from bibliography (recent and historic), but output considers all data incorporated in the database via other modules.

Biotic surveys module: Similar to the chorologic module in registering species locations, but can also record habitat types (bionomics); it also differs in being linked to a specific activity with their related metadata.

Tracking module: Manages data obtained from telemetry tracking activities, both species (turtles, large fishes, etc.) as well as moving devices (tracking buoys, etc.)

Time series & instantaneous data management module: Manages data obtained with multiparametric sensors, wave-buoys and other marine measuring devices which provide instantaneous or time data series of environmental conditions (chemical or physical, incl. hydrodynamics). It includes water-quality analysis.

Taxonomic module: Manages all information related to taxa (species, genera, families, etc.) directly embedded from WORMS, and qualified according to regional aspects of interest. Species may be native /exotic, or invasive; may be protected at different levels by local, national, European or international legislation; may be of commercial interest, etc. In addition, images of each species and notes can be incorporated. This is a core module that supports other functions (chorologic, fisheries, tracking surveys, etc.) and analytical studies. Combined with the chorological module it provides checklists (general, exotics, endemics, etc.) of fauna and flora for specific regions, islands, protected areas, etc.

Reference management module: This module manages all kind of documents in the database; those related to specific activities (reports, projects, etc) as well as published bibliography. References are linked to many other modules (administrative, chorological, surveys, etc.) but isolated; it can provide the user with access to all bibliography related to biodiversity in the region, with progressive download capacity (pdf format).

We designed the REDMIC to be used by the widest audience of people and institutions interested in the marine environment and affairs. This implies several aspects, which cannot be tackled at once, but as the REDMIC develops:

a) Making the REDMIC well-known.
b) Facilitate access & viewing information in a user-friendly manner.
c) Develop protocols for facilitating deposit /extraction of data.
d) Expand the geographical coverage to all Macaronesia.
e) Spread the concept (eventually transfer technology) of the REDMIC to other marine areas.

Points a) and b) will be considered in this Project (phase II), but the rest must wait for phase III, once the system is consolidated.

Massive data entry into the REDMIC can only start once the core administrative module, specific activity modules, and accessory modules are functional.

This data format facilitates posterior analysis of species distribution (in any kind of grid format) or to correlate species presence with other environmental variables incorporated in the REDMIC, for instance: protected areas (i.e. Natura 2000), special habitats, water temperature, chlorophyll concentrations, etc. That is the power of ArcMarine data model and what we offer to our users.

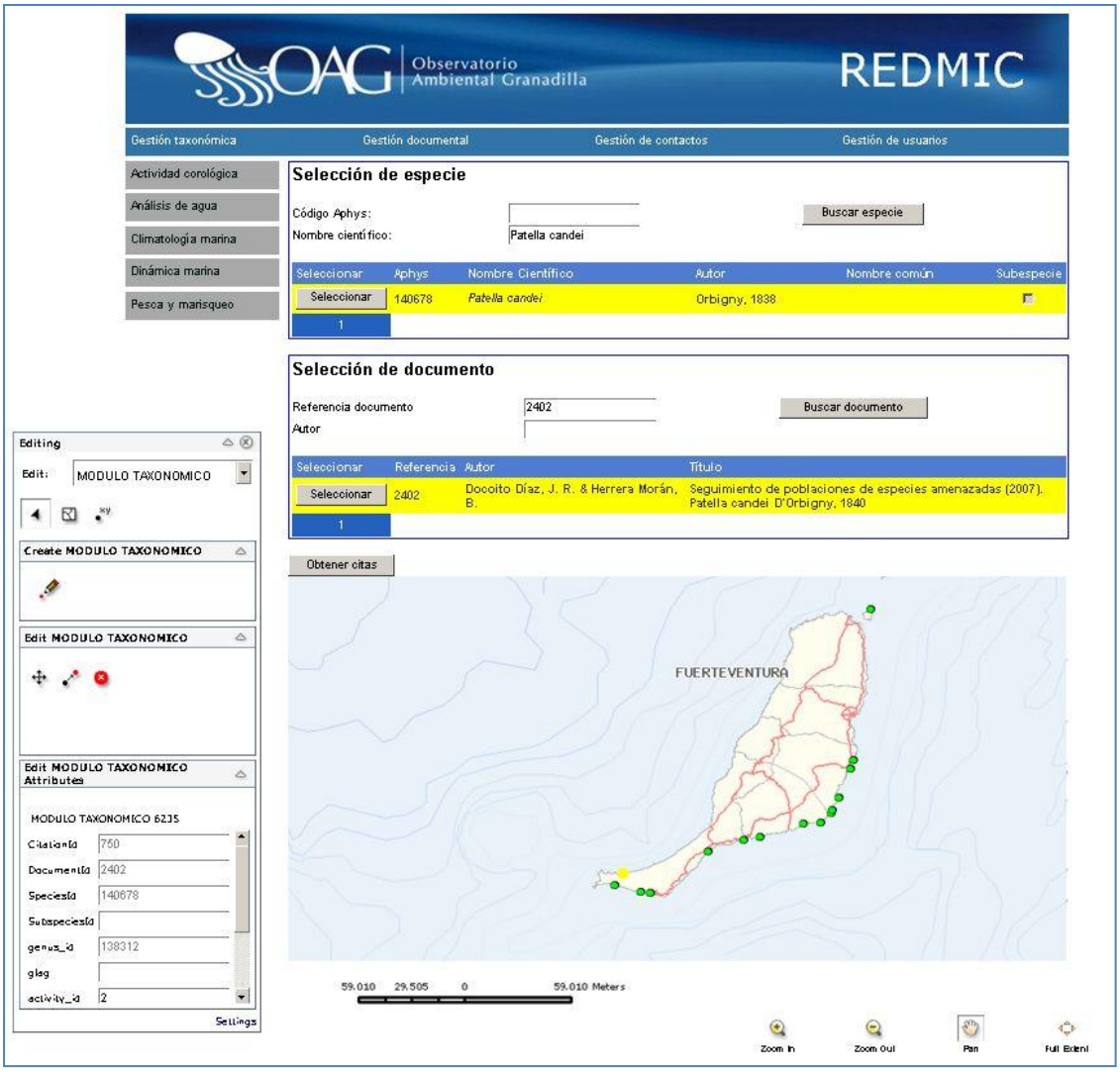

Figure 1. Data entry screen of the chorological module prototype

4 DATA TYPES

The REDMIC is presented as a single database capable of covering all areas. Data, whatever their nature, bound by the activity that generates them, and these are grouped by type of activity, with total freedom to define them. Using a common data model allows the development of analytical functionalities that access to any data whatever the activity it has generated. Data within the REDMIC can be of different nature, considering the multiple variables and environmental parameters interrelated in the marine ecosystem. A systemic analysis of data and metadata relevant to the repository is as follows:

a) Marine climatology
• Temperature and relative humidity.
• Air pressure, sunshine, etc.
• Wind strength and direction, wind transport, airborne dust, etc.
b) Physical oceanography
• Water: Temperature, salinity, turbidity, transparency, etc.
• Marine Dynamics: Waves, currents, tides, sea level, etc.
• Geophysics: Geology, Geomorphology seafloor, caves, bathymetry, grain size, etc.
c) Chemical oceanography
• Chemical composition of water (P, N, Fe and other nutrients)
• Dissolved oxygen and chlorophyll content in water
• Organic matter, salinity and pH
d) Biodiversity
• Habitats: type, benthic bionomics, disturbed areas, etc.
• Species: inventories, sightings, standings, invasions, displacements (tracking), etc.
• Conservation: Status, level of legal protection, etc.
• Data related: growth stage, biometrics, DNA, disease, diseases, etc.
• Areas of nesting seabirds.
• Data products: biological production.
• Concentration of species (jellyfish, etc.).
e) Archaeology
• Coastal: shell deposits, raised beaches, etc.
• Marine: flotsams, archaeological sites, etc.
f) Environment
• Water pollutants: heavy metals, hydrocarbons, pesticides, etc.
• Microbiological contamination.
• Concentration of litter and waste.
• Air pollutants and aerosols, NOx, SOx, CFC, DMS, etc.
• Immission/ emission of particles in the air and noise.
• Heavy oil slicks.
• Red tides or algal blooms.
g) Political and administrative data (spatial)
• Administrative demarcations: exclusive economic zone, inland waters, etc.
• Marine Protected Areas: ZEC, marine reserves, natural parks, etc.
• Fishery reserves
• Port zones: zones I and II, anchorage area, no anchorage areas, etc.
• Entities (with location): Port Authority, Police, Maritime Rescue, Red Cross, fishermen's associations, diving clubs, research centres, etc.
• Contacts: users, managers, project managers, experts, etc.
• Documentation: projects, campaigns, bibliography, expert notes, etc.
h) Infrastructure
• Measuring instruments: tide gauges, current meters, weather stations, oceanographic buoys, surveillance cameras, etc.
• Oceanographic ships.
• Permanent sampling stations.
• Port infrastructure: dams, docks, marinas, fishing shelters, piers, landing sites, etc.
• Infrastructure for leisure: beaches, surf areas, clubs and dive sites, etc.
• Waste: outfalls, illegal dumping, etc.
• Communication cables.
• Aquaculture: breeding cages, trays, etc.
• Artificial reefs.
• Other infrastructure: oceanographic platforms, wind farms, etc.
i) Use of resources
• Fish and shellfish.
• Marine farms.
• Other withdrawals: species recollecting, sand extraction, oil exploitation, etc.
j) Navigation and incidents
• Shipping routes.
• Oceanographic and research campaigns.
• Study transects and sightings.
k) Images
• Multiband satellite image
• Photo: coastal ortho-photography, incidence pictures, species, habitats, etc.
• Video: underwater transects, incidents, etc.

5 DATA FORMATS

Raw data obtained (instruments with specific software) have to be transformed to ArcMarine data model, and then to netCDF format (Common Data Form, adopted for REDMIC). There are many programs which include a specific tool of ArcEditor, that address this type of transformation, even automatically. This saves a lot of work on repetitive tasks. We need to assess which one best meets the requirements of the REDMIC.

Geo-referencing: The REDMIC adopts as standard the geographical position decimal latitude / longitude (EPSG: 4326), and from it automatic conversions to decimal latitude / longitude, or projection UTM (Easting and Northing) can be made.

Radius-point: For incorporating a level of geographical accuracy to positional data we will use the radius-point (includes radius error in meters), contained in DarwinCore, which is becoming the standard reference for species distribution (data collection, etc.).

Codes: The Ocean Data Standards (2010) has proposed, so far, only standard codes for countries, based on ISO 3166-1 and 2. The OGC (Open Geospatial Consortium) is working on a common vocabulary, non conclusive yet. Fortunately, the World Ocean Database provides a code for data status (raw, transformed, interpolated, etc.) and description for each parameter (concentrations in micromoles per litre, for instance), and its use is fairly widespread.

6 LOGICAL DATA MODEL, ARCMARINE.

Given the small geographical size to cover and the absence of operational databases in it, the most efficient solution is a centralized data system rather than distributed. In centralized systems, the power of the database depends on having a geometry common to all types of marine data that are to be integrated managed. The marine case is somewhat special (volumetric and temporal dynamics of the marine environment), compared with terrestrial logic models (points, lines and simple polygons), and varied casuistry difficult to integrate into a single model. Fortunately, there is a general model for marine data produced by organizations that have worked with specific segments of marine information and, after several years of experience, have resulted in a model called ArcMarine. ArcMarine data model is an object-oriented model that allows the development of a geographic information system (GIS) with greater flexibility than object-relational models which often support scientific information systems (SIS). ArcMarine covers the entire range of marine data (points, areas, lines raster data and time series) with XYZ and T (time), as well as incorporating information on tools that have generated the observations, campaigns, etc. The basic model, which accepts metadata, is developed in UML (Unified Modelling Language), is adaptable to any case and then exported as XML (Extensible Markup Language Interchange) and generate the template repository.

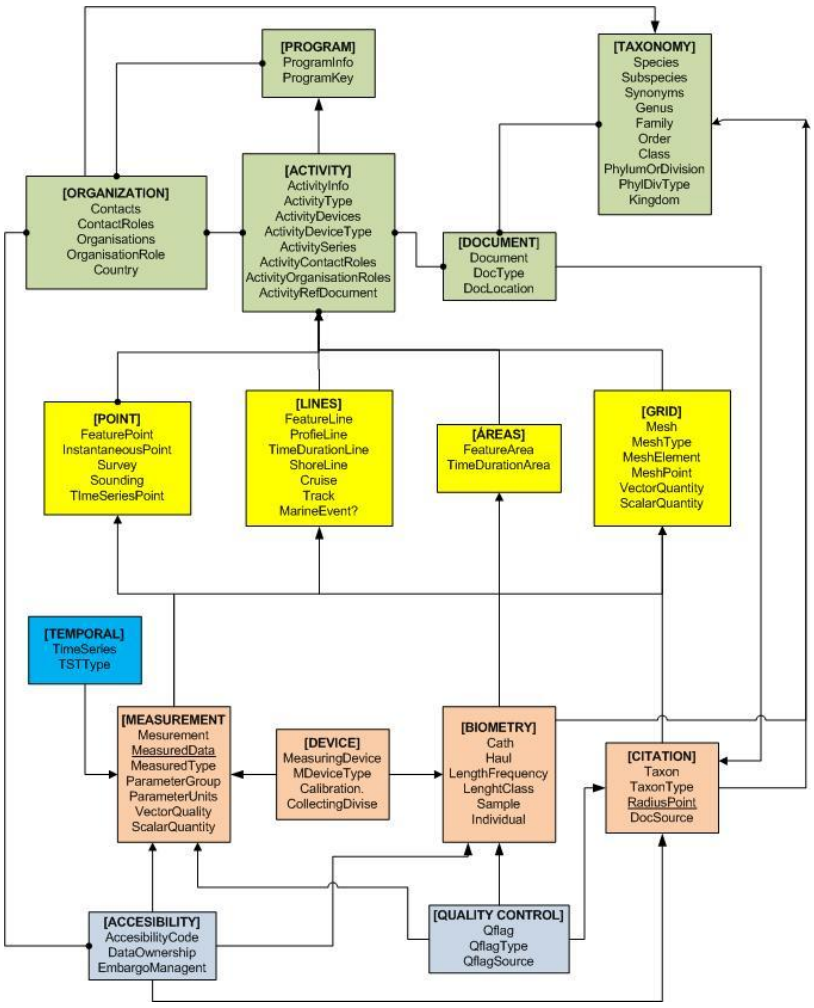

Figure 2. Logical data model of REDMIC based in ArcMarine
(Yellow = geometry; Salmon = data collection; Blue = temporal series; Light blue = supplementary tables)

7 HARDWARE AND SOFTWARE

The OAG has five high-performance Dell servers, one for backup, another as a web server, and the other three for data management (one for redundancy). In addition there are computer SAI systems, tanning hard drives, peripherals (plotters, printers, etc.), backup tapes and seven workstations, three of which are allocated to the Repository. Also the basic operating software is already available. The REDMIC can basically run with this infrastructure but almost in a "manual" form and far from its envisaged service capacity. It is based on a client-server architecture in a distributed system, which consists of clients seeking services and a server responding to requests. To optimize the process of adding data to REDMIC, the OAG will develop an interface software (several modules) using ASP. NET (the programming language chosen is C #). The application will works on the management system database Postgre Sql and has integration with ArcGIS Server 9.3.1 for the management, analysis and maintenance of geo-referenced data. Integration with ArcGIS Server will be done through the framework developed by ESRI Web ADF (Application Development Framework). We will use Microsoft Internet Information Services (IIS) and Javascript for certain tasks executed by the client. The OAG has already developed some interface prototypes, like the chorologic module, which is ready to be used and tuned-up. We adopted web technology because it provides universal access to applications through predefined user roles, making the REDMIC ubiquitous.

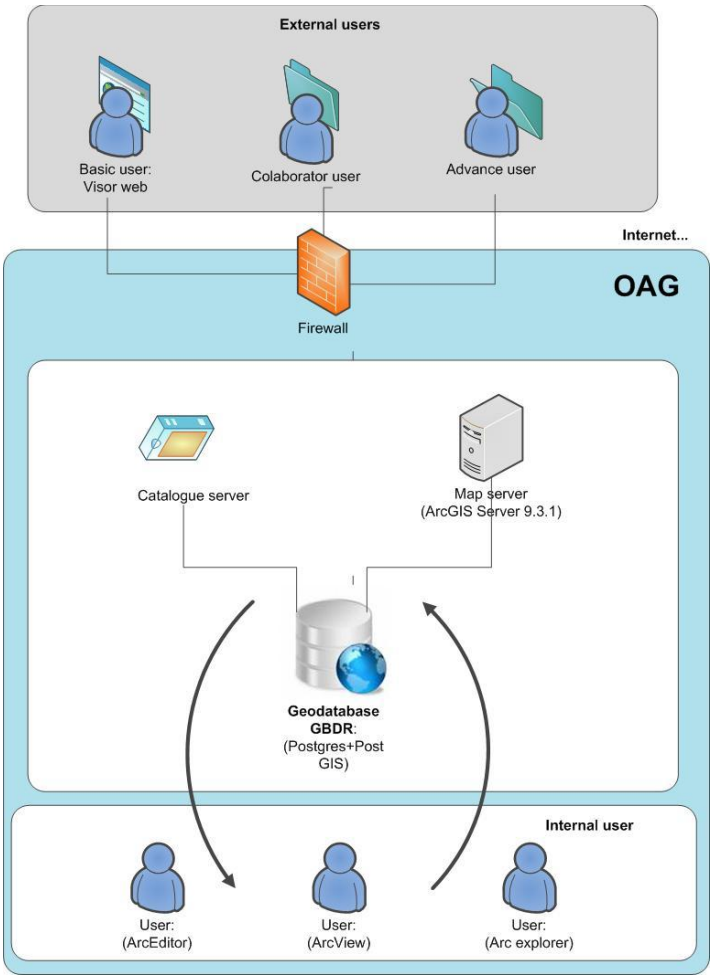

Figure 3 The REDMIC hardware architecture

8 QUALITY CONTROL

Many typical errors can affect the data: sampling error, management and storage, calibration, analytical, spreadsheet, unit conversions, parameters, without specifying what they mean, etc. Therefore, and before being incorporated into the database, the data should be reviewed in order to detect obvious errors. The verification of the data will change according to delivery in real time, delayed mode, or in the case of datasets. Many measuring devices incorporate programs for checking the data recorded, noting those which are below the detection threshold, or in excess of the number to which they belong. In other cases it is necessary the validation of experts (in chorological data, for example). REDMIC has adopted the SeaDataNet Code to express the quality of the data. This code will accompany each data and reads as follows:

0 No quality control
1 Good value
2 Value probably good
3 Valued probably bad
4 Mean value
5 Changed value
6 Value below detection threshold
7 Value in excess
8 Interpolated value
9 Missing value
A The uncertain value for the phenomenon

9 DATA POLICY

Traditionally, the ocean data are collected by a researcher who develops them (not always), publishes them in a journal (sometimes, with partial information), disseminates them in reprint format and, hopefully, the data are recovered for a general database. The modern model consists of obtaining data and, after its quality control, locating it directly on a repository from which the scientists and other users could use it. The OAG follows the basic idea that all marine data obtained with public funding are public and, in consequence, must be shared with them. Such openness -contemplated as a service to the society– will allow the maximum use of data for the future, but implies some complexity. Data access must guarantee credits to the data provider or, if that is the case, with the data owner, in compliance with any agreement established with him. This involves developing a comprehensive data policy (draft agreements, programming modules, etc.) that covers all these cases. It is scheduled for Phase III, and the basic data policy scheme is:

- Free data: Any data that can be accessed and downloaded from the repository without more restrictions than accepting the user-protocol (recognition of data source, etc.).
- Temporarily restricted data: Data whose access is temporarily restricted to certain users or provider. These data will stay under embargo and cannot be viewed or operated by other parties, unless authorized by the supplier. After this period, which shall not exceed two years, data access will be released.
- Reserved data: Data that for security reasons or linked to judicial proceedings are subject to confidentiality until the circumstances change.

The deposition of data in the REDMIC will involve acceptance of the OAG data policy and any temporary restriction on the use of data should be documented and mutually accepted. The authorship of the data will be always respected and, if so agreed, REDMIC should provide statistics on the use of datasets as credit to the supplier. If, eventually, the Spanish or Portuguese legislation require the deposit of public financed data in public repositories, the REDMIC could become one of these accredited repositories. Under that circumstance, a module to produce certificates of data deposition must be set in place.

10 USERS / ROLES

The data portal of the REDMIC is public domain, but one will have to register as a user to access the download data or to use any advanced functionality. This registration is important to guarantee that users accept the data policy of the REDMIC. Models of this type of license will be studied and adapted to the circumstances of the OAG and its associates (for compelling partnerships). Users have to agree to recognize the source and give credit to data providers when the data are used in projects or publications. Moreover, in cases where the kind of data leads to impose some restrictions on commercial use, we must devise appropriate formulas so that the data owners and users can reach financial settlements.

Normal “visitors” to the portal of the REDMIC have access to the visualization of data, but not to the datasets themselves. For direct data access the geodatabase stores information about contacts and institutions and the roles both play. The role of "user" is special and, therefore, implies the development of a specific authentication module.

- Basic user: Once registered the users will have access to the data module for unrestricted downloads.
- Collaborator: the user will have access to the general discharge modules and to the restricted data under you jurisdiction. You could receive support in data reporting.
- Advanced user (partner): the user signs a general or specific agreement of collaboration with the OAG. In addition to the features described before, the user will have access to the analytical modules and other functionalities available in the REDMIC. Also the user can receive training.

11 THE USER GEOPORTAL (WWW.REDMIC.NET)

The REDMIC has a website (http://www.redmic.net) which is essential to fulfilling its objectives of public access to information and data, as well as the best way of making itself well-known. Locating its site will be easy through Internet search engines, through the OAG's website under the tab "Integrated Marine Data Repository" or indirectly through links on the websites of the collaborators and patrons of the foundation OAG. Important access would be linked to the Canary Islands SDI, Spain SDI or European SDI, etc where links can be integrated without any problem. The user geoportal is the initial window of access to REDMIC, showing all the possibilities offered by this service. Most of them are not yet developed, but existing information has been included to test accessibility and disseminate REDMIC existence and goals.

The user will face the "Viewer", "Downloads" or "Analysis" entry buttons, as well as the "Catalog", common to these three modules, allowing for searching and selecting data in a simple and intuitive manner.

Figure 4. The REDMIC portal. http://www.redmic.net

Within the window of "Products" the user can download result of tests carried out or some finished work of general interest (sea-grass distribution maps, zoning of fish stocks, whale-watching areas, etc.). A desirable future product would be, for instance, the Marine Atlas of the Canary Islands or of the Madeiran archipelago, as promoted by the IODE (International Oceanographic Data and Information Exchange).

The provision of basic or developed information can be as wide as the data stored in the REDMIC allow. But it is logical to concentrate on that for which there is some demand, for example:

- Sea conditions (wind, waves, temperature)
- Species distribution
- Marine protected areas
- Concentration of pollutants in coastal areas
- Whale watching areas
- Fishery regulated areas
- Distribution of sea-grass meadows
- Bathing condition maps, etc.

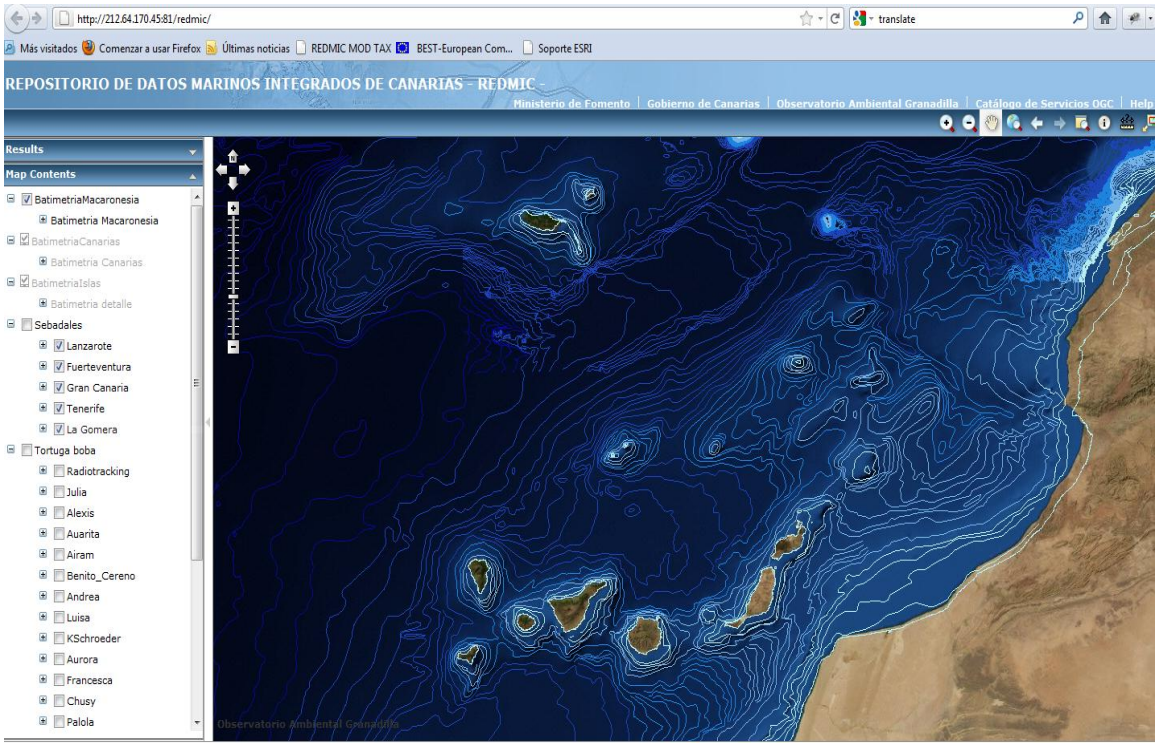

Fig. 10. Geoviewer with the bathymetry of the region

12 METADATA & CATALOGUE

Metadata are data about data; a standardized description of the characteristics of a data set. Thus, the information can be catalogued and searched for any operating system with the same standard. The REDMIC will use the European metadata standard (INSPIRE) for directories, according to the ISO 19115, to be replaced soon by ISO 19139. It seems logical to target the latest reference, while continuing the progress made in this field (http://marine-meta data.org). The REDMIC interoperability lies therein with other paternal or brother portals. ISO 19115 contains the basic model for XML format and trading schemes (XSD) for use in the Common Data Index. Meanwhile, SeaDataNet provides a Web service to validate the consistency of the syntax and semantics of metadata in the XML file and the Mikado V.1 program to assist in the generation of these files using a common SDN metadata vocabulary. GeoNetwork tool is open source and a good choice to develop the REDMIC catalogue. Now, REDMIC has a simple catalogue where the users can consult the URL of the ArcGIS map services and the web map services (WMS)

* * *

REFERENCES

Andersen, R. (2003). A GIS-based tool for coastal zone management.- Pp. 467-470 in D. R. Green, & S. D. King (eds.), *Coastal and marine geo-information systems. Applying the technology to the environment.* Dordrecht: Kluwer Academic Publishers.

Bonet, M., Cañas, R., Fuster, M., Garau, P., González, M., Tintoré, J., & Vizoso, G. (2009). La comunidad geoespacial y el acceso a los datos oceanográficos.- *III Jornadas de SIG libre.* Universidad de Girona [not published].

Breman, J. (2002). *Marine geography GIS for the oceans and seas.* Readlands: ESRI Press.

Calado, H., & Gil, A. eds. (2010). *Geografic technologies applied to marine spatial planning and integrated coastal zone management.* Azores: Universidade Dos Açores.

Damoiseaux, M. A. (2003). The management plan of the Wadden sea and its visualisation.- *P*p. 105-112 *in* D. R. Green, & S. D. King (eds.), *Coastal and marine geo-information systems. Applying the technology to the environment.* Dordrecht: Kluwer Academic Publishers.

Drapeau, L. (2008). Marine spatial data infrastructure. *Ecological Circuits* 1: 27-29.

Estrada, M., Álvarez, E., Barragán, A., Bermúdez, Ó., García, M. J., Lavín, A., Masqué, P., Pérez, F. F. & Piera, J. (2008). *Reflexiones sobre la gestión y custodia de datos oceanográficos en España. Recursos existentes y recomendaciones para el futuro.* (ID. PCI2005-A5-0141). SCOR - Comité Científico sobre Investigación Oceánica. (42 pp.) Prog. Actividad SCOR en España. Ministerio de Ciencia e Innovación. [Not published]

Fletcher, S. (2003). Managing marine resources: the role of GIS in EEZ management.- Pp. 97-104 *in* D. R. Green, & S. D. King (eds.). *Coastal and marine geo-information systems. Applying the technology to the environment*Dordrecht: Kluwer Academic Publishers.

Longhorn, R. A. (2003). Coastal/ marine GI/ GIS - A Pan-european perspective.- Pp. 35-59 *in* D. R. Green, & S. D. King (eds.), *Coastal and marine geo-information systems. Applying the technology to the environment.* Dordrecht: Kluwer Academic Publishers.

Longhorn, R. A. (2003). European CZM and the Global Spatial Data Infrastructure Initiative (GSDI). Pp. 543-552 in D. R. Green, & S. D. King (eds.), *Coastal and marine geo-information systems. Applying the technology to the environment*. Dordrecht: Kluwer Academic Publishers.

Lord Castillo, B. K. (2007). *Arc Marine as a spatial data infrastructure: A marine data model case study in whale tracking by satellite telemetry*. Oregon: Oregon State University, 175 pp. [PhD Thesis, not published]

Muto, M., Sunoda, T., & Kumasaka, F. (2010). *Development of marine spatial infrastructure in Japan. GSDI* 12 World Conference Dordrecht: Kluwer Academic Publishers [pp. 97-104]

Wright, D. J. eds. (2002). *Undersea with GIS*. Redlands: ESRI Press.

Wright, D. J., Blongewicz, M. J., Halpin, P. H., & Breman, J. (2007). *Arc Marine: GIS for a blue planet*. Redlands: ESRI Press.

*This manuscript was presented at the International Conference CoastGIS 2011 held the 5-8 of September 2011 at Ostende (Belgium***)**