THE DYNAMIC ATLAS ON THE MEDITERRANEAN MARINE AND COASTAL PROTECTED AREAS

MedGIS - a GIS and Web Map Service Prototype

Daniel CEBRIÁN-MENCHERO and Stefanie WEYKAM

MedGIS is a pilot project within the framework of the UNEP-Mediterranean Action Plan. It aims at demonstrating the capabilities of a GIS and Web Map Service for the Mediterranean marine and coastal protected areas, sites of conservation interest and biodiversity. The objective is to make the information freely available on Internet by means of an interactive mapping tool http://161.111.161.171/MedGIS/.

MedGIS includes data on the presence, abundance and composition of coastal and marine flora and fauna, habitats, related human factors, as well as the impacts and risks sensitive areas are exposed to.

At this stage, we focus on demonstrating and testing the functionalities which are interesting for the Regional Seas Programme, Mediterranean Action Plan and other user communities. Priority is given to show how data of disperse origin and formats can be displayed, mapped and queried online, while data completeness and aesthetics will have to be improved during a follow-up project.

We expect MedGIS to develop soon into a suitable tool for decision making, conservation, prevention and quick response in emergency cases.

One of the aims of this pilot project was to show how data can be shared via Internet with projects of similar interests. MedGIS will soon connect to the Mediterranean Database on Cetaceans hosted by the University of Valencia/Spain and share their maps on cetacean stranding. Additionally, we hope to establish a connection to the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea in Malta in order to include on one hand oil spill events into MedGIS and on the other hand to provide REMPEC with data on sensitive areas.

We invite other Web Services to connect to MedGIS as WMS or WFS server. The corresponding GetCapabilities-Request has been published on our web page. We are also seeking to become interoperable and compliant with other initiatives such as the World Conservation Monitoring Centre, the Global Biodiversity Information Facility, the Ocean Biodiversity Information System and Nature-GIS.

KEYWORDS

Interoperability, Web Map Service, Specially Protected Areas of Mediterranean Importance.

INTRODUCTION

Wild flora and fauna are important components of biological diversity that fulfil a variety of human and ecological needs. These valuable biological resources are increasingly threatened by unregulated human activities such as habitat destruction, unsustainable harvesting, trade and other threats.

The contracting parties to the Barcelona Convention wish to conserve the integrity and diversity of Mediterranean nature and to ensure that any use of natural resources is equitable and ecologically sustainable. The aim of the Regional Activity Centre for Specially Protected Areas (RAC/SPA) [13] consists in assisting and helping the Mediterranean countries in the implementation of the Protocol concerning Specially Protected Areas and Biological Diversity (SPA Protocol [15]) for the above purpose.

Within an effort to improve the process of data collection and periodic assessment of the situation of marine and coastal biodiversity in the region, RAC/SPA agreed on making its databases available on the Internet and circulate GIS data and, in collaboration with the CBD Secretariat, make efforts to establish a Mediterranean clearing-house on marine and coastal biodiversity that will network with the national clearing-house mechanisms and others set up within the framework of CBD [1].

Geographic analysis and spatial visualization tools give organisations the ability to provide the information that managers and decision makers need to quickly and accurately access a situation and act accordingly. Many users of GIS-enhanced applications are not GIS professionals and need custom-made, easy to use applications which can be accessed via Internet.

THE MAP INTERFACE

In order to demonstrate that a web map server can be developed at low cost, we built the web mapping system using MapServer 4.4 [5] which is an open-source CGI program, created by the University of Minnesota. The objective was to go beyond a simple display of information and to show as well how spatial data and its associated attribute data can be queried. While setting up MedGIS as GIS and Web Map Server we intended to cover as much thematic groups and data types as possible in order to demonstrate the opportunities and functionalities that such a tool can offer.

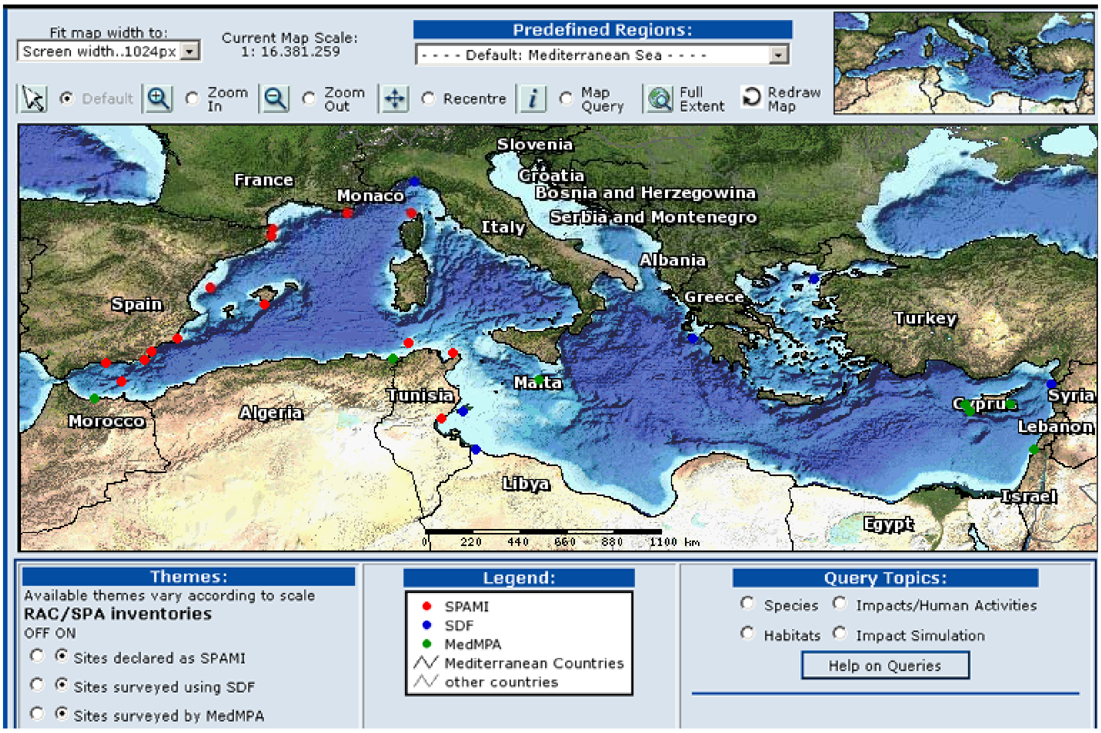


Figure 1: Map Interface

There are several map tools included which permit to amplify, re-centre, return to the full map extent or query the map. Other common functionalities are map size adjustment and scale indication, a reference map to reflect the exact location and extent of the map currently displayed as well as scale dependent feature drawing and feature labelling.

A selection list containing 16 areas studied for conservation purposes allows to zoom directly in on one these predefined regions with detailed cartography and/or satellite imagery.

Map themes appear in a list and may be toggled on or off one by one according to the user preferences. The map layers are grouped according to their character: Regional cartography (if a predefined region is selected); Restricted Data (authorized login); RAC/SPA inventories; Remote Databases (in preparation); Protected Areas (Mediterranean); Human Activities/Potential Impacts; Reference Layers; Background and Satellite Imagery (Mediterranean). The themes that are listed vary according to their availability at the current map scale. The legend is generated automatically and displays the themes and classes currently visible.

We felt that it is very important to provide some core information on the cartography and therefore included a table of data origin at the bottom of the web page. This table is automatically generated, reading the metadata of each map layer which is currently displayed: name, feature type and the responsible contributor, including a link to his web site.

THE DATABASE

Quality and quantity of the data are crucial for any GIS and its suitability as research and decision making tool. The same is true for web mapping applications. Obviously, the MedGIS prototype can neither be considered complete nor fully functional as a tool yet, but we hope to provide a first insight. We describe here the information included in the prototype version, with special emphasis on data directly derived from projects related to the Mediterranean Action Plan as well as data likely to form part of it in the future.

Most of the thematic map layers represented in MedGIS consist of spatial data files in vector format – such as the Protected Areas (point) locations, the bathymetric lines (lines) and the No-Take-Zone (area). Raster images (GeoTIF), such as the seabed model or the satellite images are composed of pixels. Regarding the seabed model and the satellite images (colour compositions) in MedGIS, the pixel values are not particularly meaningful and the images are mainly used as backdrop images to provide the user with some kind of ground reference. Nevertheless, there are raster images or 'coverages' which contain digital values that do have a meaning: sea surface temperature maps, landuse/landcover maps, digital elevation models and prediction maps. This type of spatial data is not (yet) represented in MedGIS, but very likely to be there in the future, since coverages are the adequate format for representing continuous, gradually changing parameters and many biological and ecological phenomena have this characteristic.

In those cases where a great amount of attribute data for a vector layer is available, the attribute data are best stored and read from a relational database. We chose MySQL [9]– an open source Relational Database Management System based on SQL. All information derived from survey projects and impact assessments is stored in this database while the spatial data file which represents the sites only contains some basic attributes on the site itself (name, area, declaration year etc.).

MedGIS contains data of a great thematic variety. Disregarding the reference data, we deal with data of two different categories: Natural resources and (anthropogenic) impacts and risks.

Natural resources: On one hand there are data on species level, gathered either during surveys and observations carried out with RAC/SPA support or by the responsible bodies of several protected areas. In MedGIS, the registered species are limited to some 130 species belonging to the Specially Protected Area (SPA) Protocol Annex 2 and Annex 3 for being especially vulnerable, endangered or of economic interest. All used the same list of species but additional information varied. The additional data include information on the species related to a determined location, such as if a species is rare or common at that location, migrating or breeding and the importance of the site for a particular species. The parameters within the two registering forms were different and not always comparable among each other. Anyway, the queries output both groups of data fields.

Considering that it is very likely that the inventories will be repeated and that the list of species will be amplified, special attention will have to be paid registering Zero and Null values in order to avoid misinterpretations. Zero (=absence confirmed) is not the same as Null (=not looked for). If new species are added to the Protocol between survey campaigns (for example, invasive species, ecological indicator species or important food-chain species) which have not be counted during previous campaigns but do appear later, could be interpreted as 'new arrivals' while it is actually not known whether they were present or not. Registering Zero values for absence during the surveys and Null values (database default) permits us to distinguish both cases.

There are also data on landscape composition and habitats, generally based on detailed habitat classifications (a total of 92 classes in 4 specification levels), often accompanied by area estimations (percentages at local and national levels), and sometimes accompanied by maps and spatial data files describing the location and extension of these habitats. Additionally, the data on natural resources are derived from quite diverse ecological units, such as wetlands, coastal and marine environments. Again, there were two different versions of survey data-entry forms. One distinguished between 'marine', 'coastal' and 'other' habitats (based on the Classification of Benthic Marine Habitat Types for the Mediterranean Region [2]), the other one registered marine and coastal habitats according to the Habitats Directive (Annex I [4]) of the European Commission. The Habitats Directive distinguishes fewer classes, especially among the marine habitats, while the first classification is considered more adequate. There are currently efforts made to 'translate' the Habitat Directive classes into the classification system.

The survey data on impacts and risks focus on human presence and activities (agriculture, fishery, leisure, industry, pollution) but also include natural hazards, such as erosion, forest fires, inundations, volcanism and earthquakes (177 classes using 3 levels of specification). The registers generally include the type, often accompanied by an estimation of its magnitude and origin (inside or outside the Protected Area), and a percentage of area affected. Both, habitat and impact surveys allow queries from rather generalised to very specialised classifications. I.e. the category 'Fishing, hunting and collecting' includes 8 subcategories, of which 3 are further subdivided. Queries selecting a high level class include all lower subdivisions. Despite of having only 6 sites available for proper habitat and impact queries we included this option for demonstration purposes. Efforts are made to homogenise inventories by using standardized lists and classes and by facilitating thesaurus to pick the adequate keywords in order to fill in the forms correctly. Those impacts which are of human origin (as well as some of the impacts of natural origin) directly depend on political and socio-economical pressures, related to environmental awareness on one hand and industrial development of the region or country on the other hand. One may also add to this category, all restrictions due to protection and local or national management plans, ports, marine traffic, fish exploitation, oil platforms etc. This information can possibly be completed by other UNEP-MAP Activity Centres and projects in the Mediterranean.

A data category which should be considered important due to its influence on all other phenomena is biophysical and geophysical data, such as air and water temperature, wind and current direction and speed, salinity, chlorophyll content and composition, land and water pollution, biomass, depth and elevation, soil type etc. Except for bathymetric depth, the MedGIS prototype does not yet include data of this category. Hence, given the increasing importance of Internet as information source and the opportunities emerging networks provide, there are good chances to retrieve these thematic maps and to display and query them simultaneously with MedGIS data. Especially promising are remote sensing services which provide satellite images and their derivates (landcover maps, vegetation indices, surface temperature, pollution, climate parameters etc.).

For now, most of the data included in MedGIS are data at point locations (even those which aren't really points, such as Specially Protected Areas). Species presence, habitat type or land elevation are usually taken at geographic localities, identified by geographic coordinates or place names. (Note that as for human activities and impacts, this 'point' may be a lot more fuzzy). In the case of the MedGIS survey data, this spatial reference is not directly given. Instead, each parameter has been registered to the Protected Area itself and is thus defined by the centroid (or central point) or the site. This has several advantages and disadvantages: On one hand, the low spatial precision of the data (several kilometres) allows us to freely reveal the presence of all species, regardless of their vulnerability. On the other hand, the low spatial precision makes it difficult to relate the presence of a species to other parameters (such as water depth or temperature) which in turn is necessary for habitat suitability analysis and generating distribution (prediction) maps. It is also not precise enough for management and emergency plans. However, we calculated the Maximum Error Distance, estimated as maximum distance from centroid to border, following the MaNIS Georeferencing Guidelines [16]. The Maximum Error Distance is an indicator for coordinate precision and is usually requested by networking search engines (such as GBIF [3] and OBIS [11]), although it is not mandatory.

The next task will be to recover and include the original spatial references of the inventories wherever possible. According to the characteristics of the 'subject' and the methods applied, the localisations will vary a lot in spatial precision: For example, whale sightings made at hundreds of meters distance from a boat are less precise than localisations by radiotracking of a tracked whale, which again is less precise than taking the coordinates of a stranded whale using a differential GPS. Amount of data, certainty of taxon determination, counts of individuals and positional precision depend on various factors such as the characteristics of the species itself, its population density, the survey effort and methods applied, among others. We believe that it is not adequate to represent all these localisations by points without providing the user with additional information on how this data was obtained. As for maps on species distribution or densities, it is common to display the counted or estimated number of individuals (or species or any other biodiversity indices) in form of regular spatial units, such as grids or map graticules. The spatial precision of the observation determines the minimum size of the mesh to which the data may be assigned. There are also cases in which it may not be desired to display data at its original (high) precision. For example, still unpublished data as well as sensitive data may be deliberately represented at a lower positional precision. This is often a better alternative than not showing sensitive or unpublished data at all.

Special attention deserves primary data and synthesised information. While primary data, derived by counting, measuring or observing a phenomena, are the basis for research on the subject itself, synthesized information is based on the research results, derived from statistical analysis, prediction models, data interpolation and extrapolation. This synthesised information is then often itself input for new analysis on other subjects in the same or related research fields. In MedGIS, the map layer 'Areas suspect to hold high biodiversity levels' is such an example (see: The Mediterranean Marine Gap Analysis Project [8]). Naturally, the whole Mediterranean Sea cannot be surveyed in order to identify all biodiversity hot spots. Instead a gap analysis has been conducted aiming at the identification of those areas, which according to certain criteria (spatial heterogeneity of the shelf-slope system), have an elevated probability to hold high biodiversity levels. Such synthesised information allows policy makers (especially from other disciplines) to better take nature conservation into account for decision making. Zoning categories and delimitation of areas of high conservation values is another example for synthesised information. However, these data can not yet be queried in the MedGIS prototype. We disregarded as well sampling locations and related raw data for queries in the current version, since this may be only of limited interest.

It is also noteworthy that many non-European countries are already represented in the prototype. But, while MedGIS at the present stage contains mainly data gathered inside Specially Protected Areas, it is quite obvious that these sites cannot be regarded as environmentally isolated from the rest of the Mediterranean Region which should be covered as a whole.

QUERIES

MedGIS includes several query methods which, according to the nature of the query, access either the relatively small attribute tables belonging to vector files (map tool) or the rather complex relational tables that form the database (selection lists). The user may choose between one of several query topics: species, habitats and impacts. The functionality of these options varies and depends on whether the user is currently looking at a predefined region or at the whole Mediterranean Sea:

Distribution Mapping

If the whole Mediterranean Sea is displayed, we assume that the user wishes to map the distribution of a particular species, habitat or impact type.

All survey sites at which this species is present will be marked with a symbol.

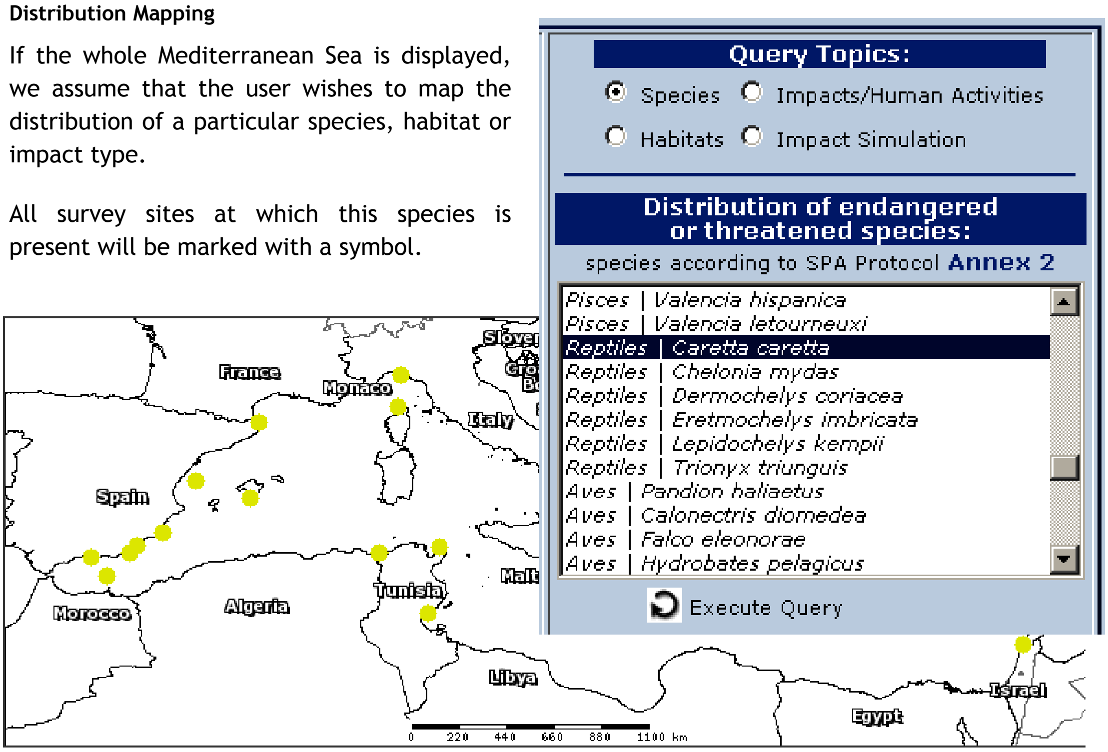


Figure 2: Loggerhead Sea Turtle distribution map

Additionally, an output table at the bottom of the page shows more detailed information: If the species is either resident, rare, common or threatened, the year the survey was conducted etc.

Distribution of habitat and impact types works just the same, except that there are different levels (from rather general to very specific) at which the user may make the selection: For example, the

QUERY RESULTS:
Trawling found at:

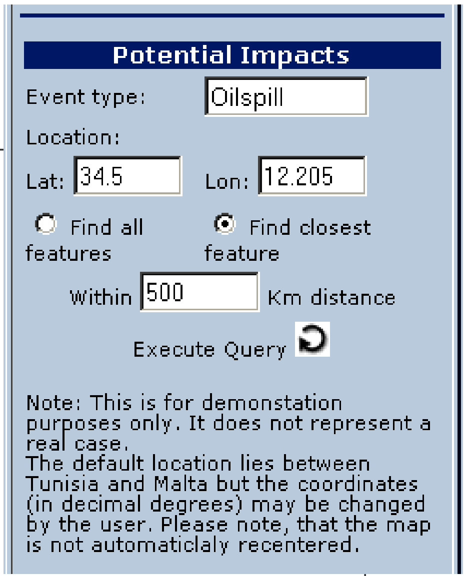
Code	Impact Category	Impact Description	Name	Country	Intensity	% exposed	Influence	Location	Survey Year	Survey Project
212	Fishing, hunting and collecting	Professional fishing: Trawling	Promontorio di Portofino	Italy	High influence		Negative	Outside	2002	SDF
212	Fishing, hunting and collecting	Professional fishing: Trawling	Gökçeada - TÜDAV Marine Park	Turkey	High influence	100	Negative	Inside	2004	SDF
212	Fishing, hunting and collecting	Professional fishing: Trawling	Gökçeada - TÜDAV Marine Park	Turkey	High influence		Negative	Outside	2004	SDF

Figure 3: Query result table

user may choose 'Fishing, hunting and collecting' and get in return anything that falls into this category. Or she/he may as well be only interested in 'professional fishing' and particularly in 'Trawling'. In the latter case the query will only return this particular type of fishing. If the user has chosen a habitat type, she/he gets information on the area covered by this habitat and it's importance, while regarding impacts the user learns about how much is exposed to it, the intensity and whether its inside or outside the park.

Within-Distance Query: A special case is the last option: an oil spill simulation. The objective was just to demonstrate how one can find and identify any features (all or just the closest feature of each theme) which are located within a determined distance to a particular point location. The oil spill is a hypothetical case and we didn't consider neither wind nor current speed and directions.

The user may create his own disaster simulation by indicating other coordinates and distances, in order to see what would be affected and how far away it is.



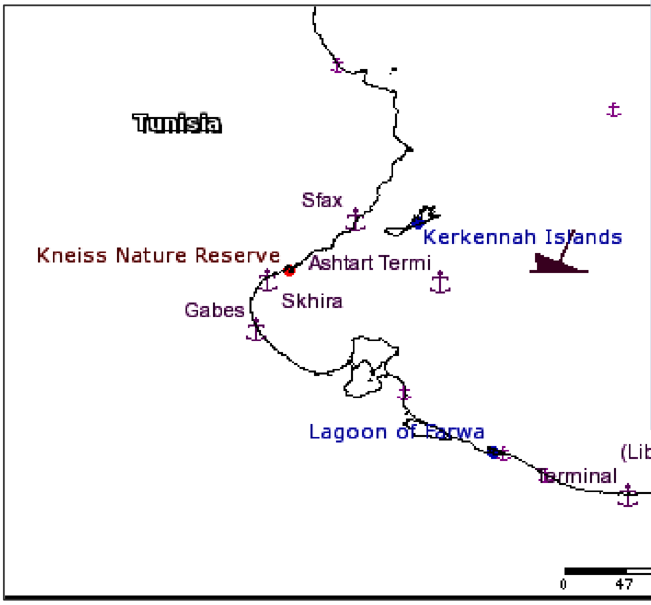


Figure 4: Simulation – identifying affected features

In the future we will hopefully link MedGIS to the REMPEC [14] oils-database, so that the simulation will be finally replaced by real locations. Anyway, this type of query may be very interesting for decision makers, since it shows all potentially affected features within a determined area even before the event occurs.

Checklists at predefined regions

If the user is looking at one of the predefined regions, we assume that she/he wishes to get a checklist of all endangered or threatened species or a list of habitat types or human activities and impacts on the area. So, instead of sending the selected name(s) to the database the user just executes the query and retrieves the required list directly.

QUERY RESULTS:
Zakynthos Marine National Park, Greece

Code	Habitat Type	Representativity	Conservation Status	Vulnerability	Coverg.[%] within the site
II.3.1.1	Facies of banks of dead leaves of P. oceanica and other	Non-significant presence	The habitat is very discontinuous and the assemblage is sparse and residual	Medium	1
III.2.2.2	Association with Halophila stipulacea	Significant	The habitat is very discontinuous and the assemblage is sparse and residual	Low	1
III.5.1	Posidonia oceanica meadows (= Association with Posidonia oceanica)	Excellent	The habitat is continuous and the assemblage compact	Low	35
III.6.1.2	Association with Cystoseira amentacea (var. amentacea, var. stricta, var. spicata)	Good	The habitat is continuous and the assemblage compact	Low	5
III.6.1.20	Association with Sargassum vulgare	Excellent	The habitat is continuous and the assemblage compact	Low	10

Figure 5: Query result table: Habitat checklist

MEDGIS AS SERVER AND CLIENT

One of the aims of this pilot project was to show how data can be shared via Internet with projects of similar interests. MedGIS will soon connect (as web client) to the Mediterranean Database on Cetaceans (MEDACES [7]) hosted by the University of Valencia/Spain and share their maps on cetacean stranding. Additionally, we hope to establish a connection to the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (REMPEC) in Malta in order to include on one hand oil spill events and generic risk maps into MedGIS and on the other hand to provide REMPEC with maps on sensitive areas.

We invite other Web Services to connect to MedGIS (wms and wfs available). The corresponding GetCapabilities-Request has been published on our web page (see: About the Data). MedGIS also seeks to become interoperable and meet the standards of other initiatives such as the World Conservation Monitoring Centre (UNEP-WCMC [17]), the Global Biodiversity Information Facility (GBIF), the Ocean Biodiversity Information System (OBIS), Nature-GIS [10] and other networks related to the Clearing House Mechanism of the CBD.

CONCLUSIONS AND FURTHER DEVELOPMENTS

It may appear somewhat risky to combine sets of so diverse data themes. An adequate integration requires certainly a very high degree of coordination between the different centres and working groups and homogenisation of data gathering and exchange. Great efforts are already underway to coordinate and achieve synergy. But, doesn't this enormous information diversity call for a subdivision of MedGIS? We believe that a service which combines all factors relevant for protection and conservation of habitats and biodiversity is indeed very important. For researches and decision makers, it does not suffice to know which species are present at a determined site. They also need to know what affects them in one way or the other. More precisely, we need to be able to combine the knowledge of experts of different disciplines. The possibility to integrate teams of various disciplines into one network, able to act and react in real-time, is certainly a great challenge.

It is currently considered to evolve into a network formed by the several MAP Activity Centres [6] on which data are shared but yet have various data access portals instead of one that tries to suit them all. According to their expertise, each of these portals would serve different data sets, and some of the data are obtained from other centres. Each portal would thus simultaneously be server (own data) and client (external data). This network type would preserve most of the advantages of the distributed system with one common portal, except that the user has to choose –according to his/her interests- which portal to visit, since the available information will not be identical. Additionally, it permits that each centre presents to a maximum their own data and expertises, hence counting on contributions from other centres of the UNEP-MAP frame. The services not necessarily have to be designed and financed exclusively for and by UNEP-MAP, nor are the members of the network obliged to evolve in concordance. They may simultaneously satisfy other national, European or global projects and initiatives as long as all implement international (OGC [12]) standards. Each centre with expertise on a particular field (for example: oil spill monitoring or satellite image processing and vegetation mapping, coastline changes, socio-economic indices and human activities) may provide other nodes with high quality and reliable, homogenised information, avoiding thus loss in time and resources and data duplication. The externally retrieved – shared – data would consist primarily of synthesised maps, while primary data itself had to be queried at its 'home'-portal. Besides, data and metadata losses during data transfer can be reduced or avoided. As a side effect, it will assure a better data registration, dissemination, data storage and update. The benefit of data sharing would be immense, since part of the data could be provided by other MAP members via Internet. Ideally, each node would contribute with synthesised information (rather than huge amounts of primary data) to a better understanding of the marine and coastal environment. Perhaps the main advantage of such a network is to bring the different expert groups closer together. An improvement in data availability and usage creates new management and research opportunities. In other words - the whole is more than the sum of the parts!

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AUTHORS INFORMATION

Daniel CEBRIÁN-MENCHERO
daniel.cebrian@rac-spa.org.tn
Marine Biology Expert
United Nations Environmental Programme
Mediterranean Action Plan,
Regional Activity Centre for
Specially Protected Areas,
Tunis, Tunisia

Stefanie WEYKAM
stefanie@weykam.net
Consultant,
Regional Activity Centre for
Specially Protected Areas
Madrid, Spain