SeaGIS Abruzzo: A publicly available atlas of marine uses and natural resources in the Adriatic Sea Region

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Abstract

In the Adriatic Sea, the European Union supported a cross-border cooperation research program, during which digital spatial data on shellfish production and relaying areas, regulated conditions on fishing activities, protected areas and restocking structures, administrative boundaries and sea bottom characteristics, were collated from digital repositories in various institutions and paper documents. A web-based geographical information system was developed to share data of the sea facing the Abruzzi region and to explore the spatial distribution of marine resources and maritime activities, thus focussing and facilitating fisheries management and providing a potential support to the regional planning of resource exploitation.

Video link

https://www.youtube. com/watch?v=2axYJQFlI-0

Background

Marine coastal and offshore areas are subject to a growing pressure by numerous stakeholders for different purposes, including harbours and shipping, production of energy from renewable sources, exploitation of oil and natural gas deposits, sediment extraction and disposal, fisheries and aquaculture, environmental protection and tourism (De Freitas and Tagliani, 2009; Katsanevakis et al., 2011). This convergence of multiple interests poses new challenges to make the development of human activities compatible with the safeguard of natural resources, as they compete for the same valuable space.

In many cases, the attempts to balance different interests and assess compatibilities have been hampered by difficulties using available data and information and by sectoral policies adopted by institutions and stakeholders.

This does not mean that all the activities carried out in sea areas are not regulated or that no rational or fair space allocation is performed: on the contrary, many regulations exist, but they are predominantly confined to conventional economic sectors (Douvere, 2008) or traditionally managed case-by-case. In the European Union (EU), a framework for Maritime Spatial Planning (MSP) was established by Directive 2014/89/EC, which integrated Directive 2008/56/EC, also known as the Marine Strategy Framework Directive. These Directives lay down guidelines for achieving compatibility between the development of economic activities and the need to safeguard marine resources for future generations (Piroddi et al., 2015).

Fisheries are one of the economic activities that have to face a competition for space, due to fleet overcapacity problems, decline of fish stocks and reduced profitability. Fishing areas should be defined by a flexible approach, in accordance with the changes in fish stock distribution patterns, while aquaculture activities require specific reserved areas (Aswani and Lauer, 2006).

A research project, related to this context named *Protection, improvement and integrated management of the sea environment and of cross border natural resources* (ECOSEA), was developed

between 2012 to 2016 as part of the framework of the *Instrument for Pre-accession Assistance* Adriatic cross-border cooperation program, Intervention Area 2 - Protection and enhancement of the marine environment and coastline (http://www.ecosea.eu/it/). The ECOSEA project involves six Italian regions, two counties in Croatia, and the Ministry of Environment, Forestry and Water Administration of Albania. Its general objective is an improved management of the natural resources of the Adriatic Sea through the cooperation between border regions, within the common framework of the EU Common Fisheries Policy. One of the project specific objectives is the collection of digitalized information on the use of coastal and offshore areas in the Adriatic Sea, with particular attention to fisheries activities.

In the Abruzzi framework of ECOSEA activities, the authors developed a geographic database to collect and retrieve data and spatial information concerning the exploitation of marine and fishery resources in the stretch of the Adriatic Sea facing the Abruzzi region, central Italy. A web-based GIS application, named *SeaGIS Abruzzo* was developed to easily display and share the collected data with all possible local stakeholders, and was made available as thematic interactive geographical maps.

WebGIS allows data integration across diverse traditional disciplines and provides a framework of information collected for a variety of specific purposes (Carollo *et al.*, 2009).

This spatial information can be gathered from many sources and assembled in a unique WebGIS application (Katsanevakis *et al.*, 2011), which can represent the core of decision support systems for environmental and marine management (Tuda *et al.*, 2014) or can allow the simulation of alternative management scenarios to evaluate and prioritise interventions. A spatially organised database, together with web-based visualisations, may intuitively reveal possible spatio-temporal trends or relationships that would be more difficult to discover in tabular or other formats (De Freitas and Tagliani, 2009). Data and webGIS are elements to be integrated with other relevant data (biological indicators, water quality, socio-economic features, remotely sensed data) (Ruddick *et al.*, 2014) and implemented in numerical modelling (Soma *et al.*, 2013; Piroddi *et al.*, 2015; Brigolin *et al.*, 2017) to quantitatively support the MSP.

The WebGIS system simplifies and unifies access to data for managers, stakeholders and politicians and facilitates ecosystem-based management. Even if the interaction among these actors is not straightforward, the knowledge exchange among scientists and decision makers would be very relevant (Cvitanovic *et al.*, 2015), with the common goal of maintaining marine ecosystems in healthy, productive and resilient conditions (Katsanevakis *et al.*, 2011).

Content of SeaGIS application

Data for the coastal area facing the Abruzzi region were collected on the following thematic areas: i) Protected areas and restocking structures; ii) Sanitary classification of shellfish production and relaying areas; iii) Regulated areas; iv) Areas subject to environmental impact; v) Administrative areas; vi) Characteristics of the sea bottom.

To develop the features, a standardized workflow was adopted: i) assessment of most recent legislation and identification of relevant data for the region of interest (spatial selection of the information); ii) digitalisation of the geographical boundaries of the ele-

ments; iii) population of attribute tables; iv) production of metadata; v) validation of information.

The list of layers, the source of the data and a brief description of the layer content are reported in the following Table 1. Each layer is equipped with references to the original source of data, provided as links in the attribute tables.

Description of SeaGIS application and user access

The WebGIS application is publicly accessible by clicking on the *SeaGIS Abruzzo* link, provided in the Abruzzi Region fisheries homepage (http://www.regione.abruzzo.it/pesca/) or directly at http://mapserver.izs.it/gis_ecosea/. The interface allows to navigate the data, the base maps and allows to overlay the layers. The application is in Italian language, being dedicated to local stakeholders.

The layers in SeaGIS Abruzzo are exposed as open geospatial consortium (OGC) standard web services, that is Web Map Service (WMS). The services containing each layer are exchanged in image or vector format on the internet, and can be integrated into other applications, in many system platforms or into desktop geographical software. Similarly, the SeaGIS Abruzzo application can receive and display data from third party sources provided as OGC compliant web services. The metadata files associated with each layer are accessible by clicking on the *M* symbol next to the layer name: general information on the layer, date of creation, language, geographical extent, a brief description of the layer content, and the reference person or organisation responsible for the creation and maintenance of the metadata are available.

Potential use of SeaGIS application for the management of marine resources in Abruzzi Region

The MSP Directive 2014/89/EC was adopted by the Italian Government with the Regulation n. 201 of 17 October 2016. Since January 2016, SeaGIS was made available to the permanent advisory Regional Committee on Fisheries and Aquaculture of the Abruzzi region as a complementary tool to support decisions on the allocation of marine space.

The coast of Abruzzi region is about 120 km long in the central part of Adriatic Sea. It accommodates space for several human activities, including fisheries and aquaculture (production and harvesting areas of mussels and other bivalve molluscs), together with marine and terrestrial protected areas. In the coastal zone, within the territorial waters (12 nautical miles), platforms for oil and gas extraction and related pipelines are present as well as dumping areas and underwater sewage.

A first potential application of the SeaGIS system was tested in the area facing the Giulianova harbour, where new sites for shellfish farming were identified according the complexity of already existing maritime activities as well as considering the sanitary status of edible Bivalves Molluscs in the farms and natural banks in the area (Figure 1).

In the system, indeed, the layer *Classificazione delle acque per la molluschicoltura* reports the sanitary status of the molluscs according to the EU Regulation 854/2004. The Regulation establishes the official control programmes for bivalve molluscs and it sets out the requirements for production and placing on the market

of live bivalve molluscs in the EU. This ensures that marketed shellfish are either derived from high quality areas (class A, green coloured polygons) or appropriately treated prior to sale to ensure the reduction of microbiological pollutants (class B, yellow colour, and class C, in red and not present along Abruzzi coast).

Outlook

SeaGIS Abruzzo represents a focus point for marine spatial planning in the Abruzzi region, improving the preparedness toward the implementation of the most recent legislation. The system facilitates the updates of such MSP with specific information on the status of marine resources, actually becoming a management tool for food safety and animal health. Such integrated system can also be useful to plan effective actions facilitating the adoption of appropriate targets for monitoring plans and helping the description of future scenarios in risk modelling. These data are the core dataset needed to be combined in spatial modelling able to assess

Table 1. List of SeaGIS Abruzzo layers, with data sources and a brief description of the layer content.

Thematic area	Layer name	Description	Data source
Protected areas and restocking structures	Seagrass meadows	Locations where the presence of *Cymodocea nodosa* has been notified	Carla Giansante, scientific internal report IZSAM 9840/2009
	Restocking structures	Artificial reefs for restocking	Polygon digitalised from scientific reports of Doc U.P. Pesca project (EC 2792/1999)
	Protected Areas	European inventory of *Nationally designated areas*, holding information about protected areas. The layer includes: the Marine Protected area *Torre del Cerrano*, six Sites of Community Importance in the coastal area, and three natural reserves on the land, close to the coast	Original shapefile data at http://www.eea.europa.eu/data-and-maps/ data/nationally-designated-areas-national-cdda-8 (accessed: 3rd December 2015)
Classification of shellfish production and relaying areas	Mariculture	Marine areas with mussel and other bivalve molluscs breeding	Polygon digitalised from official documents of the local Harbour Office
	Mussel Classification	Sanitary classification of natural clam (*Chamelea gallina*) banks	Polygon digitalised from official documents of official institutions (Abruzzi provision no. 807 of 05.12.2014)
Regulated areas	Regulated Areas	Areas with specific regulations on fishing and other sea-related activities (*i.e.* anchoring areas where transit, fishing and other activities are banned)	Polygon digitalised from official documents of the local Harbour Office
	Forbidden areas	Areas in which fishing activities are prohibited due to territorial and sea bottom characteristics (pipelines, cables, platforms, bathing areas)	Polygon digitalised from official documents of the local Harbour Office.
Impacted areas	Explosive sites	Area with old or recent unexploded war devices	Polygons designed at IZSAM, on the basis of 2014 prefaction to the notice to Mariners, Italian Navy Hydrographic Institute
	Dumping areas	Disposal sites of harbour dredged sediments	Shape project Adriatic Atlas administrators - Emilia Romagna Region
	Underwater sewage	Extension of sewer pipes and average load associated data	*Azienda Comprensoriale Acquedottistica SpA*, Pescara
Administrative areas	Harbours	Major ports and harbours	Shape project Adriatic Atlas administrators - Emilia Romagna Region. Original data collected from the ISPRA database
	Coastline and reef breakwaters	Adriatic coastline at a national level of detail	Shape project Adriatic Atlas administrators - Emilia Romagna Region. The Italian coastline, edited by ISPRA, drawn by photointerpretation (1:5000 - 1:25.000 scale) from IT2006 flight (www.pcn.minambiente.it)
	Fishing sectors	Fishing areas related to harbour fishing administrative entities	Polygons digitalised at IZSAM, on the basis of *D.P.R. 1st March 2005, n. 51*
	Territorial waters	Territorial waters: a belt of coastal waters extending at most 12 nautical miles from the Italian baseline	Shape project Adriatic Atlas administrators - Emilia Romagna Region. The drawing was carried out according to legislative instructions, but the result cannot be considered as official, since there is no official Italian territorial sea baseline
Characteristics of the sea bottom	Wrecks	Most relevant wrecks potentially dangerous for fisheries	Points designed at IZSAM, on the basis of Italian Navy Hydrographic Institute and notice from the local Harbour Office
	Bathymetry	Underwater depth of the Adriatic Sea, reference scale 1:750,000	CNR - Institute of Marine Science (ISMAR), Bologna (Trincardi *et al.*, 2014)

ISPRA, Italian National Institute for Environmental Protection and Research; CNR, National Research Council.
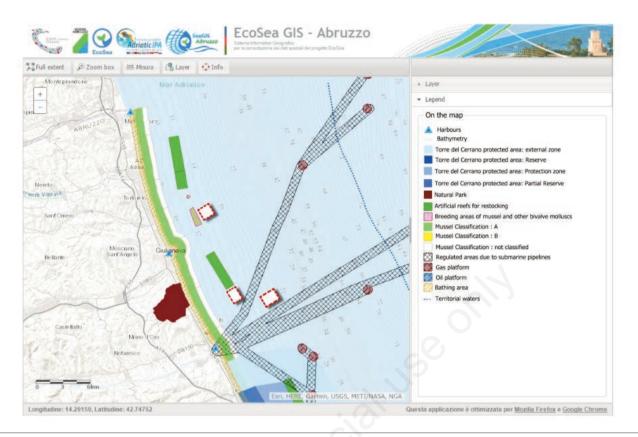
Figure 1. Potential sites for new shellfish farms (white square, red dashed border) identified near Giulianova harbour.

shellfish site suitability.

This communication consists of this text and a short video with the aims to share its content with a wider range of stakeholders and to facilitate the communication of WebGIS functionalities to government offices. The system background, the available datasets and the main functionalities and possible interactions are visualized in the video. It concludes with a practical session showing how the data from the WebGIS can be integrated into a local GIS desktop (QGIS) through a Web Map Service.

Overall aim

GIS represents a useful tool to implement the MSP, since it can display, overlap and analyse different types of information, comparing many data at the same time. Moreover, it has multi-scale capabilities, allowing the storage, manipulation and integration of large amounts of data and simplifying data maintenance and information sharing.

The WebGIS *SeaGIS Abruzzo* was developed to easily display and share the collected data concerning the exploitation of marine and fishery resources.

Software

Data did store into the Oracle 10g Database Management System, directly connected to the GIS server (ESRI® ArcGIS Server 10.2). The information did then make available as standard Representational State Transfer (ReST) Map Service, in the form of georeferenced map images (Web Map Service - WMS).

The client application was developed using ESRI® ArcGIS API for JavaScript to manage the layers and jQuery to realize the user interface and to perform AJAX calls to the server-side resources. The WebGIS client application was made publicly accessible with a generic browser and it integrated the high spatial resolution tiled map services of ESRI® ArcGIS Online. The WMS is available for users who want to consult the data independently from the WebGIS application. Metadata files did compiled using the Metadata Editor available on the INSPIRE Geoportal (inspire-geoportal.ec.europa.eu/). The video was produced with Camtasia Studio 9 software (TechSmith Corporation, Okemos, MI, USA).

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