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## OGC Open Standards and Oceanography in Spain

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### **Abstract**

Within the Spatial Data Law of Spain, LISIGE, the role of oceanographic, aquaculture and marine data is considered as essential for the EU INSPIRE Directive implementation. OGC web services, as one of the best sources of service metadata, is a reference for Sensor Web Enablement (SWE), Web Coverage Service (WCS), Web Feature Service (WFS), Web Map Service (WMS), Web Processing Service (WPS), Catalog Service for the Web (CSW). The move towards the ubiquitous use of these data products in Spain, will allow the public access to the information gathered by the oceanographic network. This communication is based on the search of OGC services made by crawling the main search engine results, web pages from geoportals and metadata records when available. The strategies to easy share oceanographically referenced thematic information between organizations, enlarge the digital scenario. This phenomenon is consistent over time, in spite of deficiencies in adequately document the discovery services. Specifically, the SRW/SRU interface for exposure of repository content is already apparent in the Spatial Data Infrastructures (SDI) examined. A number of service providers (National SDI, Regional SDI, Provincial SDI, Academia, National geoportals, Map hostings) are sharing and using interoperable oceanographic data to the benefit of the community.

**Keywords:** OGC standards; Sensor Observation Service (SOS); Web services; Spain; Oceanography

## 1 Introduction

Managing geo-referenced data by activating WMS, WFS and other OGC services require on land, in the laboratory, to afford with a problem of data fusion methods, that at sea is a bigger problem due to much more limited shipboard resources and options (Helly 2011). Some of these problems include fisheries and aquaculture in their coverage and have been considered in the past by the librarians (Brueggeman 1996). In the nowadays context where open access is encouraged, data acquisition focus on "demilitarized zones" in internet searching to implement solutions to these problems.

<sup>1</sup> Connecting natural phenomena across spatial scales require to provide easy access to time, specially from scientific intranets on the ships, and on the basis of an editorially controlled publication process for geospatial data. The actual rate for transmission of data from vessels to the central servers in land is around 0.5€/connection. And by virtue of their clearly defined work area, ocean libraries offer an opportunity to work at the frontier of such cyber-infrastructure efforts, by looking for editing based on user rights and the license (Ellenbroek 2015).

The need for change in the management of long-term scientific data whilst complying with the requirements of the EU INSPIRE Directive on data sharing and compatibility (Haft 2015), makes it feasible to choose the library as a combined data and information archival and publication platform. The employ of digital object identifiers to implant the OGC geo-processing services, the use of portable systems to manage the onboard data, its applicability to mobile ad hoc networks are all well-defined chapters inside the annotated bibliographies available in recent years from the information and reference services (Dietz 2010).

Spanish Oceanographic INSPIRE-Compliant OGC Services		
	URL	Bibliography
RAIA observatory Oceanographic Observatory of the Iberian Margin	<a href="http://www.marnaraia.org/">http://www.marnaraia.org/</a>	(Bastos et al. 2016)
IEOOS: the Spanish Institute of Oceanography Observing System	<a href="http://www.indicedeafloramiento.ieo.es/index_en.html">http://www.indicedeafloramiento.ieo.es/index_en.html</a>	(Tel et al. 2016)
Pasaia metocean station website	<a href="http://estacion.itsasnet.com">http://estacion.itsasnet.com</a>	(Sagarminaga et al. 2012)
Coastal Information System of Andalusia	<a href="http://laboratoriorediam.cica.es/VisorGenerico/">http://laboratoriorediam.cica.es/VisorGenerico/</a>	(Iglesias-Campos et al. 2011)
ESTOC Observatory. Canary Islands Oceanic Platform (PLOCAN)	<a href="http://siboy.plocan.eu/ESTOC">http://siboy.plocan.eu/ESTOC</a>	(Déniz-González et al. 2014)
Atlas of marine biodiversity in the Balearic Sea	<a href="http://www.ba.ieo.es/bioatlasmarino/atlas/">http://www.ba.ieo.es/bioatlasmarino/atlas/</a>	(Deudero et al. 2011)

**Table 1:** OGC services for Oceanographic Data under INSPIRE Directive in Spain

In Spain, the lack of a catalogue containing all the identified sources of oceanographic data, the fact that the INSPIRE-compliant catalogues are not up-to-date and because they are not designed for datasets held in non EU states or for datasets related to land surfaces, together with the complexity to search these datasets, may have discouraged the partners to look for the description of collections in it. Nevertheless, for the visualization of the Spanish oceanographic data under INSPIRE Directive, services are available from the RAIA observatory (Bastos et al. 2012), the Spanish Institute of Oceanography Observing System (IEOOS) (Tel et al. 2016), the Atlas of Marine Biodiversity in the Balearic Sea (Deudero et al. 2011), the ITSASGIS-5D marine spatial data infrastructure (Sagarminaga et al. 2012), the geo-referenced data at the Directory of Atmospheric, Hydrographic and Biological datasets for the Canary Current Large

Marine Ecosystem (Déniz-González et al. 2014), the coastal and marine information system of Andalusia offers from an early date INSPIRE-compliant OGC Services (Iglesias-Campos et al. 2011) (**Table 1**). So the five sub-regions into which Spanish waters have been divided (the North Atlantic, the South Atlantic, the Canary Islands, the Levantine-Balearic and the Gibraltar Strait and Alborán Sea sub-regions, are offering the Catalogue Service Web (CSW), Web Map Services (WMS), Web Feature Services (WFS) and Web Coverage Services (WCS).

## 2 LISIGE, the role of INSPIRE ocean data

The Infrastructure on Geographic Information Infrastructures and Services in Spain (LISIGE) law was adopted in 2010 (Masser, Crompvoets 2015). This transposed the INSPIRE directive and created the legal and institutional framework for INSPIRE implementation. This task is the responsibility of the Executive Board of Geographic Information Infrastructure of Spain (CODIIGE) and has been implemented via the creation of a number of Technical Working Groups. Concerning oceanography this means that LISIGE organized several Thematic Working Groups (TWG) to propose recommendations on how to promote the publication and sharing of geographic information on:

1. the aquaculture facilities
2. the oceanographic geographic regions, which provides the physical conditions within the oceans (currents, salinity, wave heights, etc.)
3. the sea regions with the physical conditions of seas and saline water bodies broken down by regions and sub-regions with common characteristics

In support of these duties derived from LISIGE, both the Ministry of Agriculture (directorate general of agricultural markets) and the Navy Hydrographical Institute under the Ministry of Defense coordinate the members of these groups (TWG) within the scope of the Law.

This is the consequence of the fact that LISIGE has two basic differences respect to INSPIRE Directive because it promotes the publication and sharing of geographic information (Capdevila, Muñoz 2012), and because the concept of Reference Data is defined and included, and so all identifying information about specifications for the spatial data for oceanography, in conformity with INSPIRE-LISIGE, is within the ISO 19115 Topic Category Code "oceans".

OWS NAME	URL	JIIDE WS Year
IDECanarias (Canary Islands SDI)	visor.grafcan.es/visorweb	2009
IDE marm	sig.magrama.es/geoportal	2011
IDEC-Litoral (v.2)	www.geoportal-idec.net/idecostes/index.jsp	2011
Faros	www.farosproject.eu/registro.aspx	2011
Menorca Island SDI	ide.cime.es/visorIDE	2012
MeteoSix	visor.marnaraia.org	2012
GIS of the Port of Barcelona	planol.portdebarcelona.cat/gisweb	2013

**Table 2:** Oceanographic OGC Web Services (OWS) as presented at the Spanish JIIDE Workshops (2005-2015)

The workshops JIIDE, co-organized by the INSPIRE Thematic Clusters & the Spanish SDI Team/IDEE, for the putting into practice of the requirements of the directive (INSPIRE) and the

Law (LISIGE), have been held since 2004 (**Table 2**). From this year on, local information systems for the oceanographic policy formulation and implementation were consolidated into Spatial Data Infrastructure (SDI) called IDEE, which complied with OGC specifications thus enabling the access and consultation to the catalogues of metadata. A 2004 free access service for the Catalan site of Sitges was the first geographical server based on the standard ISO 19115 (capture and generation of metadata), a WCS client (internet catalogue server) and a WMS Client (map server). Available information and evidences on this first, reveal that it was presented at the 37th CIESM Congress, organized in June 2004 in Barcelona. This initial effort was part of the European initiative for sustainable coastal erosion management, EUROSION (Serra et al. 2004).<sup>2</sup> A first experience for the publication under OGC standards promoting sector-specific data, while keeping the particularities of oceanography, it must be mentioned as the first step of a successful long-term strategy.

Spanish commitment to implement the Open Geospatial Consortium interoperability standards for oceanography goes one step further in 2009, when IDECanarias (Canary Islands SDI) made its map production line accessible through the Web Map Service (WMS). After that in 2011, the Spanish Ministry of the Environment and Rural and Marine Affairs presented its SDI project. IDE marm acts for the defence and the promotion of fishery production, and offers a beaches services guide in Spain, inundation maps for marine related hazards, and maritime-terrestrial public domain management tools. All these OGC services use the ISO19128 - WMS 1.3.0. Inspire profile. Close to its 10th birthday offering OGC services, the Coastal Information System of Catalonia (IDEC-Litoral) presented in 2011 the second version (v.2) of its geoportal for the littoral (Cuesta, Giménez 2012).

In the spirit of building a marine SDI, CSIC (the Spanish Council for Scientific Research) advanced a CSW to integrate metadata from the data acquisition system in Spanish Oceanographic Research Vessels; the catalogue was connected to two sources of data: THREDDS (so guaranteeing interoperability in the SeaDataNet framework) and GeoServer (Soto et al. 2011).<sup>3</sup> A Geoportal to promote a responsible management of fishery with 0 discards on-board, the project FAROS launched by IEO (Spanish Institute of Oceanography) with the support of Galician and Portuguese marine science institutions, was intended to implement complete OGC services but the implementation was stopped before it was finished. Instead, the Menorca Island SDI arrived to provide its own solution to the OGC services implementation (Cardoso Santos et al. 2012).

Funded by the Galician Government in December 2009, MeteoSix is a meteorological and oceanographic forecasting and observation geo-information SDI through OGC (WMS, WFS, WCS, SOS...) and non-OGC (NetCDF Subset, OPeNDAP...) services; also it was presented in the JIIDE 2012 Workshop (Regueiro et al. 2012). The digital cartography of the Barcelona harbour was presented in 2013, by exposing the OGC services offered through its geoportal (GISWEB).

The Steering Council of the Geographic Information Infrastructure in Spain (CODIIGE) Technical Working Groups (TWGs) provides oceanographic sectors to help better supply OGC Services. The Agency's expertise covers areas such as facilities and infrastructures (beacons or signals to aid maritime navigation, data managed by the State ports authority (Ports of Spain, <http://www.puertos.es/es-es/oceanografia/Paginas/portus.aspx>)), and digital elevation models (based on data sets that include sea floor bathymetry, but not the coastline topography).

### **3 Ocean Science and OGC Standards (WMS, WMTS, WFS, WCS, WPS, CSW, SWE)**

In order to meet the needs of creating an information inventory of oceanographic OGC services in Spain, a first question will be what these norms mean. By replacing the download-reformat-display paradigm, the Open Geospatial Consortium (OGC) focuses on melding environmental datasets into mapping systems.

OGC has defined several types of services:

- Web Map Service (WMS) for serving collections of layers as map images
- Web Map Tile Service (WMTS) for serving map layers as cached map tiles
- Web Feature Service (WFS) for serving data as vector features
- Web Coverage Service (WCS) for serving data as raster coverages
- Web Processing Service (WPS) for serving geospatial processing
- Catalog Service for the Web (CSW) for interoperability with other portals
- Sensor Web Enablement (SWE) for discovery and publish alerts

An additional question is where are the OGC services for oceanography in Spain? To find, download and visualize the available layers it must be taken into account that in Spain much metadata are not INSPIRE-compliant, and that language is Spanish in spite of the fact that IGN-Spain (the Spanish National Geographic Institute) has created an INSPIRE discovery service (<http://contenido.ign.es/csw-inspire/srv/eng/main.home>).

Since 2005, oceanography research has taken advantage of OGC standards and a number of Spanish web provide access to ocean data by making use of services that delivers images of data (like WMS) or that optionally can deliver data (WFS, WCS). In oceanography as a community of practice, members come from formal structures and processes where the business and technical requirements for geospatial interoperability are under the umbrella of the defense and intelligence (D and I) sector. Barcelona received a D and I DWG (Domain Working Group) forum for discussion along the sessions of 2015 OGC Technical & Planning Committee (TC/PC) Meeting hosted by the Autonomous University of Barcelona (UAB), where an INSPIRE Compliance Agenda was also included (<http://cite.opengeospatial.org/m20150311>). A Meteorology and Oceanography Domain Working Group was established in 2009, but Spain is not a participant.

Finally, the Spanish oceanographic community is making use of the OGC Sensor Web suite of standards, especially the Sensor Observation Service (Sorribas et al. 2012); MyOcean and SeaDataNet data spaces are sources for contributors.

### **4 Spain, crawling search engines, geo-portals, metadata records**

To meet Spain's obligations under INSPIRE, the government has developed a number of services including an external facing web catalogue service, and spatial search and preview services. Also have been created and maintained re-usable technical components to help data providers and publishers to meet their INSPIRE obligations. As in oceanography sharing and interoperation are necessary then OGC as universally adopted standards are been applied.

The availability of oceanographic information accessible in open standards from OGC, is focused on the use of web search engines, crawlers. The general purpose web crawlers (such as Heritrix, Nutch, and Labin), aim to download any web pages obtained through the hyperlinks,

while focused web crawlers or topic-specific web crawlers intend to download as many web pages relevant to the given topic automatically and keep the amount of irrelevant web pages downloaded to the minimum.<sup>4</sup>

Few services are focused on providing data about the number of servers implementing OGC services for oceanography (López-Pellicer et al. 2012). A research agenda of difficulties include (Hofer 2015):

1. decide on the granularity of components of workflows
2. difficulties to accept data sources provided by users instead of locally managed sources
3. the size of files security issues related to data provided online

Using crawlers different designs are conceivable in which keyword search is used to locate an initial set of pages. Although the results of the geospatial focused crawler prototypes for the discovery of OGC services for oceanography in Spain were not relevant<sup>5</sup>, the crawler can also be designed for commercial search engines.

Then crawling the Web restricted to the discovery of WMS, WCS, WFS and CSW servers, brought in the selected layers from the OGC services; and those complete HTTP URLs that includes the OGC service's Name. The commercial search engines queried were Bing (formerly Microsoft Live Search), Google and Yahoo! (**Table 3**). The queries were made through two discovery strategies (Lopez Pellicer 2011):

**Basic strategy:** queries for tokens that may appear in the query fragment of a GetCapabilities request to an OGC Web service plus additional terms related to the task (e.g. "oceanography getcapabilities").

**Expert strategy:** queries to documents where the tokens must appear in the URL of the document (e.g. "oceanography inurl:getcapabilities").

These technical results, on the number of OGC Web services discovered by using commercial search engines, are scarce; a context which highlights that there is no low-energy solution to the problem of supply OGC background examples in oceanography, under the form of an exhaustive catalogue based on the crawling procedures. Thus, in the following sections we opted to select out from each known site up-to-date data concerning active OGC Services.

	Google (BSC-EXP)	Bing (BSC-EXP)	Yahoo (BSC-EXP)
WMS	42 - 31	24 - 1	30 - 30
WCS	1 - 12	5 - 0	4 - 4
WFS	5 - 5	6 - 0	5 - 0
WPS	1 - 0	0 - 0	0 - 0
CSW	6 - 6	7 - 0	6 - 0
SWE	5 - 8	1 - 1	1 - 11

**Table 3:** Number of results and discovered resources by crawling with commercial search engines.

## 5 Examination of the Spatial Data Infrastructures (SDI) and identification of the SRW-SRU interface

As an example of a major SDI, INSPIRE problems around data-compliance provide a basis to benchmark three oceanographic data spaces: EMODNet, SeaDataNet, Copernicus (MyOcean). But the results have been scarce when measured against the question on the implementation of OGC Services in Spain.

A Marine pilot INSPIRE compliant SDI has been developed, that provides an insight into the WFD (Water Framework Directive) coastal monitoring network in Spain, Valencia (<http://inspire.ec.europa.eu/index.cfm/newsid/11608>). As a marine SDI its principal aim is the exchange of an access to (spatial) data. Specifically the marine pilot takes the generic resources and applies them to the context of MSFD (Marine Strategy Framework Directive). The results are a suite of training materials, reports and demonstrations. A framework for action this Marine pilot is a result of a closer collaboration between EMODNET and INSPIRE, and tries to solve the problem of Member States looking towards EMODNET and Copernicus to provide Inspire compliance on their behalf.

Spanish responsibilities in OGC standards implementations for MyOcean has resulted in that a protocol OGC/WMS has been validated for being plugged on MyOcean Web portal, and a latest version (1.3.1) deployed at Puertos Del Estado (<http://maya.puertos.es/oceanotron/Godiva.html>). The result was presented at the Fifth SeaDataNet TTG meeting together with Emodnet's Technical Working Group that took place in Barcelona (Spain) the 19-20 March, 2014 (Agenda: [http://www.emodnet-chemistry.eu/barcelona\\_19-20\\_march.html](http://www.emodnet-chemistry.eu/barcelona_19-20_march.html)).

The EMODnet project team partners represent the EuroGOOS, MyOcean and SeaDataNet groups providing OGC services (WMS, WCS, and WFS) for viewing and distribution. Spanish participants are the Spanish Institute of Oceanography (IEO (MINECO)), Puertos del Estado-AEMET (MAGRAMA), the Mediterranean Institute for Advanced Studies (CSIC-IMEDEA (UIB)) and the Marine Technology Unit (CSIC-UTM (MINECO)).<sup>6</sup> In EMODNET-Bathymetry, the Balearic Islands Coastal Observing and Forecasting System (SOCIB, Balears-Spain) provides an example of usage of WMS as base layer for display where marine observation instruments are deployed. In EMODNET-Chemistry, the Marine Technology Unit supplied a follow-up of the status of Sensor Web Enablement (SWE) RONIMAR program station located in Cádiz with a tide gauge (CSIC coordinated SWE initiatives within SeaDataNet). **Table 4** summarizes the specific marine institutions providing OGC services and coming from Spain in the three examined major data spaces.

Spatial Data Infrastructures (SDI)				
	IEO	CSIC	Ports of the State	Ministry of Defence
EMODNET	21	5		1
SeaDataNet	27	17	3	
Copernicus			3	

**Table 4:** Composite data sets produced and delivered by Spanish Oceanographic Institutions and complemented with OGC services to serve EMODNET, SeaDataNet and Copernicus users.

The profile SRW of OGC Catalogues for oceanography in Spain was confronted with the many catalogue services' implementations profiles and standards available inside OGC (Z39.50, CORBA-IIOP, SRW or CSW (SOAP, XML-Post and KVP)); to develop systems with the

capacity for connecting with on-line catalogs that use real implementations INSPIRE-compliant (Nogueras-Iso et al. 2005). But nowadays the IDEE Catalogue Spain is a OGC CSW 2.0 (ISO 19139) INSPIRE compliant product (<http://www.idee.es/csw-inspire-idee/srv/spa/catalog.signin?node=srv>). Its architecture includes a SRW Adapter ISO-Profil and IDEE Metadata contributors eventually must change their SRW driver to access the IDEE catalogue server. As far as is recommended for future marine atlas services to include WFS and CSW, it seems natural that no official Spanish involvement should be scrutinized in relation to SRW/SRU issues in oceanography, at this moment.

## **6 Examination of National SDI, Regional SDI, searching for shared and used interoperable ocean data**

Spanish regions have been developing their own Regional SDI, establishing the National Spatial Infrastructure of Spain (IDEE) to implement INSPIRE (Mezcua-Rodriguez 2009). The metadata catalogue of the Spatial Data Infrastructure of Spain, includes a "marine areas" INSPIRE theme that provides 112 metadata layers as mechanisms to describe both the sea bed and sea surface as well as inter-tidal areas and the shoreline. After a summary **Table** (Appendix), the main available URLs for these OWS resources were transcribed.

### **6.1 Regional Level**

#### **6.1.1 Andalusia**

REDIAM, the Andalusian Environmental Information Network provides OGC services concerning oceanography and it is a regional node of IDEE in Andalusia. This infrastructure supposes an important pillar of implementation of EU directive INSPIRE in Andalusia, and besides the Catalogue Service Web (CSW), it offers: Web Map Services (WMS) (2166 services: Environmental Maps (1953 services); Orthophotographs (66 services); Orthoimages (43 services)).

One of the WMS Area of special environmental interest is the coastal and marine environment:

- coastal waters quality indicators (from satellite images): annual-, seasonal-, monthly-means sea surface Chlorophyll-a concentration, (downloadable files in KML and KML viewer), diffuse attenuation coefficient, superficial sea temperature (27 services)
- management procedures for the environmental protection of the littoral (2 services)
- morphology and bathymetry (9 services)
- hydrodynamics (2 services)
- biology (12 services)
- coastal vulnerability indexes (3 services)
- socio-economic and soil uses (20 services)
- Almeria littoral region maps (7 services)
- Guadiana estuary (7 services)
- Lower section of river Guadalquivir (5 services)

Local WMS services are supplied like a series of orthophotos of the Andalusian coasts: Huelva, Cádiz, Costa del Sol, Granada and Almeria as much as of the Guadiamar river (Seville) and the Doñana Natural Park.

Web Feature Service (WFS) (14 Services)

OGC-compliant WFS clients can access the data published across the web through a WFS platform "areas of environmental interest (littoral)" ("WFS Ámbitos de Interés Ambiental:

Litoral"). 46 layers can be downloaded, including soil and coastline maps, harbor public domains, bathymetries, marine currents in the Andalusian coasts, submarine vegetation, marine and oceanic water mean salinity, zooplankton and chlorophyll, gaseoducts, oleoducts, electrical and telephone wiring in the Andalusian marine waters, fishery and navigation restriction zones. Download formats: Shape, Gml, GeoJSON, Shapezip.

Web Coverage Service (WCS) (18 services)

As a tool for vigilance of eutrophication in the marine ambience, a WCS Service offers all the images from the AQUA MODIS satellite filtering the historical series for Chlorophyll in the period 2000-2010. It permits the estimation of phytoplankton concentration and biological activity in the Atlantic ocean and the sea of Alborán. Download formats: BMP, GIF, IMG, JP2, JPG, JPEG, MPL, PNG, RST, TIFF.

With these Andalusian OGC Services a cartographic viewer at sub-regional scale has been designed for the Spanish waters corresponding to the Gulf of Cádiz and the Alborán Sea from the border with Portugal in the mouth of the Guadiana River to the south of Cape Gata including the Straits of Gibraltar. Building research links between the EU and US, OGC are used for the generation of interoperable services concerning the erosion vulnerability in Andalusian beaches as a result of climate change.

Much INSPIRE-compliant Andalusian results can be searched from the Regional SDI (IDEAndalucía) metadata catalogue.

### **5.1.2 Basque Country**

The remote sensing service for inshore fishing (oceanictxiki) integrates the Basque Country Operational Oceanography System (owned by the Directorate of Emergency Attention and Meteorology of the Basque Government). It makes use of OGC standards.

The Basque Country's SDI (geoEuskadi), considers from its catalogue of data and services: wms online information on the shoreline boundary (it includes two viewers, and FTP service) a coastal cadastral wms service is announced. Additional ISO 19115 INSPIRE compliant oceanographic information refers to: marine habitats (served through downloadable cartographic layers elaborated with bathymetric and acoustic reflectivity) and 2009 marine bathymetry online information downloadable via FTP. All this OGC Services INSPIRE-compliant information is searchable from the "Océanos" entry at the CSW geoEuskadi metadata catalogue. Seaside beaches online information can be accessed through the geoEuskadi viewer by listing the "health and safety" layers.

### **5.1.3 Canary Islands**

All the information is available from the IDE Canarias metadata catalogue. Canary Islands regional government SDI offers:

- WMS shellfish harvesting closure areas
- WMS sea dumping
- WFS geodetic network
- WPS digital elevation model

The Canarian territorial information system (IDECanarias) map viewer offers:

- bathymetric cartography (coming from the Spanish Oceanographic Information (IEO))
- a visualization of the shellfish harvesting closure areas

- the location of sea dumping
- a specific security and emergency viewer, with access to the coastal contamination risk layers
- access to the beaches and ports of the Canary Islands' coast demarcation of maritime-terrestrial public domain

The island of Gran Canaria has its own SDI (IDEGranCanaria), which offers a viewer (v 4.1) and a WMS for the design and use of harbor spaces in the island.

Otherwise, the Port Authority of Santa Cruz de Tenerife offers OGC services from its Granadilla Environmental Observatory (OAG). WMS layers are offered for bathymetries, coastal toponyms, lighthouses and fog maritime signages. At the digital atlas of Tenerife entries are offered for INSPIRE themes "sea regions" and "oceanographic geographical features" but no maps are supplied.

#### **5.1.4 Cantabria**

OGC services offered by the geographical information service of the Cantabrian regional government provide the geographical layers for the coastline areas of interest. The more geo-registered map images are elaborated with data from the Navy and concerns the official coastal line. All the available interoperability services can be accessed from the SDI map viewer.

#### **5.1.5 Catalonia**

From the Directorate for Maritime Affairs and Fisheries in the Regional Government, a INSPIRE visualization services OGC-based server offers the cartography of the geographic information system for the aquaculture and oceanographic data (SIGPesca) in the waters of the Catalan sea, and for the sea surface temperature and chlorophyll data (THALASSA). 21 map layers are available from SIGPesca, and 6 are accessible from THALASSA. Users can have free and gratuitous access to these OGC Services. Now this same Directorate guarantees consistent updating of the information concerning fisheries through the use of the WMS (Web Map Service) developed for the Department (which can be opened with a GIS program).

The IDEC (the Catalonian SDI) Map Server implements OGC Services (WMS, WCS and WFS) which are offered in 3 formats, GeoRSS, KML, and HTML; it provides 55 map layers for the coastal WMS service (Atermenament Litoral (DTES)).

#### **5.1.6 Galicia**

The Galician SDI, IDEG, is engaged with both the INSPIRE thematic clusters "oceanographic geographical features" and "aquaculture installations". But no OGC services are offered on these subjects, from the regional searching engine. If the checking of the OGC Services is made against a consultation of the service directory (<http://mapas.xunta.gal/directorio-de-servizos>) IDEG offers:

Web Map Services (WMS) (29 services)

8 of the WMS services publish the coastal cartography (but no details on biological communities or erosion analysis are supplied). The provision of GIS services on lighthouses, harbors and beaches is available by using the OGC viewer.

Web Feature Service (WFS) (2 Services)

OGC-compliant WFS clients can access the data of the river basin district of the State Coast Demarcation in Galicia through one WFS platform. Otherwise, by using the IDE Galicia metadata catalogue, GeoNetwork open source allows to:

elaborate interactive maps on oceanographic geographical features based on speeds of marine currents estimated by high-frequency (HF) radar in Galicia (data are provided by the Galician network of oceanographic stations monitored by Intecmar, which supplies it through a Intecmar Thredds Catalog; these data are subjected to errors and a permission for its use must be obtained from 'Puertos del Estado'. Intecmar, the Galician technological institute for the control of the marine environment is oriented to provide web services based on INSPIRE Directive and offers:

- a CSW Discovery Service;
- a OGC-WMS Server, three more OGC-compliant services for data visualization (WMS) (network of Galician oceanographic stations, micro- toponymies, and fishermen's cooperatives). The map viewer tool of the GIS displays the layers on rafts, infauna, and epifauna.

#### **5.1.7 Balearic Islands**

IDEIB, the Spatial Data infrastructure of the Balearic Islands offers (3) functional, (21) specific and (13) thematic OGC services. These services of visualization began to work in June of 2008, and official calculations indicate that they support more than 2 million consultations to the month. OGC services at oceanographic data node of IDEIB are:

Web Map Services (WMS) (2 services)

They include Nautical charts and the General Bathymetric Chart of the Oceans (GEBCO) data for the Western Mediterranean Sea. Additional WMS services are orthophotos with positional data on recreational fishing pressure, seabed habitats, surface of the beach marine communities and for the survey and demarcation of the maritime-terrestrial public domain. Orthophoto basemap of posidonia (WMS) are also available. To visualize these layers specific thematic viewers are accessible from the Menorca SDI, the Majorca SDI and Balearic Government SDI.

#### **5.1.8 Murcia Region**

IDERM, the SDI for the Murcia region, has a directory for finding OGC Services that includes WMS visualization services. The INSPIRE ocean thematic cluster is listed, but no OGC service is offered. From the territorial information system (sitmurcia), and with a regional planning point of view a WMS service concerns the maritime-terrestrial public domain. sitmurcia offers a INSPIRE-compliant CSW Discovery service, which shows the orthophotos of the littoral. The implementation of a web feature service (WFS) to download the directives for the littoral is previewed. These regulations and the coastal demarcation can be examined by using the sitmurcia viewer.

#### **5.1.9 Principality of Asturias**

SITPA, the SDI of the Government of the Principality of Asturias, offers a WMS on the state of the beaches. The result can be accessed through a GIS viewer. The OGC services offered by the Organisms and Systems Biology Department (University of Oviedo) are listed in the Spanish IDEE Metadata Catalogue.

Web Map Services (WMS) (7 services)

Surface chlorophyll variations in the Atlantic Ocean and Biscay Gulf between 1998 and 2007, Sardine larvae abundance, the herbarium database (algae, lichens, bryophytes, etc.), and the

RADIALES project data series (chemical-biological conditions in the Asturian continental shelf).

Web Feature Service (WFS) (1 Service)

The distribution of sardine larvae can be downloaded in form of digital map, as much as the analysis and sample methodology used.

### **5.1.10 Valencia**

terrasit, the portal of the Valencia SDI (IDCV), apparently offers 36 entries under the INSPIRE theme "Oceans", but it turns out to be results unconcerned with oceanography. Nevertheless, 49 layers under INSPIRE cluster "Oceans" are offered when the search is made from the regional Government geo-catalogue (<http://geocatalogo.cma.gva.es/geonetwork/srv>); although, coastal planning and sea farming are only for internal use.

Web Map Services (WMS) (1 service)

Beaches, coastal lines and blue flags. The viewer of the IDCV offers access to the marine cartography of the Instituto Franklin, University of Alcalá de Henares.

## **5.2 National Level**

### **5.2.1 IEO, Spanish Institute of Oceanography**

IEO has experience in developing product and services for different users working in consonance with INSPIRE (Tello et al. 2016). Open Geospatial Consortium (OGC) standard services (Thematic Realtime Environmental Distributed Data Services server (THREDDS), Geoserver) are available to facilitate the access to in-situ data and model output. Using this infrastructure an ad-hoc web data-geoportal was developed (<http://www.geo-ideo.ieo.es/geoportalideo/catalog/main/home.page>); its search engine identifies 9 wms services. A suite of products for the general public, and more specific for the aquaculture, marine leisure, fishing and commercial users, can be reached ([http://www.indicedeafloramiento.ieo.es/index1\\_es.php](http://www.indicedeafloramiento.ieo.es/index1_es.php)) in demonstration and forecast mode. With downscaled models are produced upwelling and frontal maps for fisheries, beach status information for marine leisure pursuits ([playas.ieo.es](http://playas.ieo.es)) and real-time warning of impending conditions to the shellfish producers in the Galician Rias ([www.asimuth.eu](http://www.asimuth.eu)). Data and products are disseminated through web applications some of them ready for smart phones.

### **5.2.2 MAGRAMA, The Ministry of Agriculture, Food and Environment**

Aquaculture and oceanographic data are provided with OGC Services from a directory of services of the coasts and marine issues in the Ministry of Agriculture (MAGRAMA), this is a Inspire Directive compliant visualization services catalogue. The maps returned by the WMS services available from this directory are images whose geographic layers display:

- the official system governing the maritime-terrestrial public domain
- the risk of coastal flooding maps
- a guide to the beaches in Spain

The geo-registered map images (returned as JPEG, PNG, etc) obtained as response to the request can be displayed in a browser application. MAGRAMA does not use the WFS protocol to download geo-referenced map images generated from marine data, but the ATOM encoding standard. ATOM is a basic form of Web page that sends news headlines like RSS, and has been adopted by the Open Geospatial Consortium (OGC).

### 5.2.3 CSIC

WMS, WFS and CSW OGC services for developing oceanographic mapping services have been created by CSIC; not only to store and retrieve data generated by marine models but also to serve as an integrative mode to view the output information in an OGC standard manner.

This community has developed a profile of OGC services as part of the Soil Moisture and Ocean Salinity (SMOS) mission of the European Space Agency (ESA). In the Barcelona area, WMS can be accessed and rendered using a Web-based Godiva system, and can also be downloaded in netCDF file format through a thredds server (<http://cp34-bec.cmima.csic.es/ncWMS/wms?SERVICE=WMS&REQUEST=GetCapabilities&VERSION=1.1.1>). The Mission was initially operated from russian Plesetsk cosmodrome and it is a web based INSPIRE compliant service.

The development of WMS, WFS and CSW OGC services, uses different free software (Open GeoSuite, GeoNetwork, CatMDEdit, GeoServer...) at the Coastal Ocean Observatory (COO). Assessment in data and metadata following INSPIRE rules and standards, and data management in real time is achieved by using Sensor Web Enablement tools. In the COO Thredds catalog, files of AVHRR 2001-2016 data from NOAA and EUMETSAT/METOP satellites, acquired at the Coastal Ocean Observatory project, are freely available both in ncWMS and ncWCS formats (<http://cooweb.cmima.csic.es/thredds/wms/cooweb/2015/01-Jan/29/20150129.0201.n19.nc?service=WMS&version=1.3.0&request=GetCapabilities>).

OVIDIO (Oceanographic Vessel Wireless Data Integrator) a data discovery theme to develop a profile of 19139 for metadata generation is a OGC with INSPIRE extensions download service (<http://ovidio.imedea.uib-csic.es/ovidio/metadata.html>).

An additional implementation of OGC services (WMS, WFS and WCS), including a Sensor Observation Service (SOS), is offered for real-time data and instrument description from UTM-CSIC Research vessels (García et al., 2010).

## 6 Conclusions

Concerning the 8000 km of Spanish coastline, an assessment of the number and distribution of OGC Web service (OWS) in the oceanographic communities confirms that existing policies make it difficult to obtain access to real-time and near-real-time data. Shape with areas where open access is not encouraged, make the design of "demilitarized zones" not only important with documentation and archival purposes but also in relation with low-cost focused crawlers with ability to discover standard geospatial processing systems. Although it must be confessed that there is a loss to discover OGC services concerning Spain and oceanography by using crawler-based technology, and that there is no low-energy solution to the problem of identifying active OGC services in this area.

At this moment in Spain, the information is being encoded under INSPIRE-compliant standards as a spatial reference system. OGC has enabled the oceanographic community to achieve a high level of data interoperability. But OGC standards need to be expanded to explicitly provide for error management, and automate the labor-intensive data processing required for using the web for visualization.

As emerging technologies OGC services become easier to use, and public service professionals of all kinds are increasingly tasked with them, these technology-mediated exchanges play an important role in how geospatial information is perceived and used. To a variety of international data spaces, security requirements limit the ability of scientists to access and control critical parts of an operating system, or to unambiguously specify a limited set of map products of an ensemble of maps, each of which is a possible alternative for the same time and location. By situating discussions within a framework for decision-making, in order to be relevant to a broad audience, in Spain we need new approaches to provide reliable and convenient access to OGC services for oceanography.

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## Notes

1. The Spanish Army provides a sustained OGC services support from its Geoportal of Spatial Data infrastructure (<http://ideihm.covam.es/geonetwork/srv/eng/main.home>).
2. Readers are referred to the specific discussion introduced by local conditions data provided by OGC Services by contrast to those designs of tailor-made coastal erosion management solutions like the supplied by the United States Army Corps of Engineers Coastal Engineering Manual (2001) (USACE 2001).
3. Concerning the specific difficulties on how to deal with oceanographic features by using SDI, see (Rodríguez Pascual et al. 2007).
4. These free programs allow the user to view OGC services: Gaia, uDig and Esri ArcGIS Explorer Desktop.
5. Trying to find OGC WMS, WFS, WCS services (see <http://www.opengeospatial.org/blog/2034>) these are the Web crawlers where searches were performed :  
Spatineo Directory (<http://directory.spatineo.com/>),  
PolarHub (<http://polar.geodacenter.org/polarhub/>),  
and GEOSS Portal ([http://www.geoportal.org/web/guest/geo\\_search\\_overview](http://www.geoportal.org/web/guest/geo_search_overview)).
6. MINECO, Spanish Ministry of Economy and Competiveness; MAGRAMA, Ministry of Agriculture, Food and Environment; University of the Balearic Islands (UIB).

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Appendix

OGC Services	
IDEE Marine Regions (csw)	<a href="http://www.idee.es/csw-inspire-idee/srv/spa/catalog.search#/search?inspiretheme=Regiones%20marinas">http://www.idee.es/csw-inspire-idee/srv/spa/catalog.search#/search?inspiretheme=Regiones%20marinas</a>
<b>IDEAndalucia</b>	<a href="http://www.ideandalucia.es/catalogo/inspire/apps/buscador/formulario/">http://www.ideandalucia.es/catalogo/inspire/apps/buscador/formulario/</a>
REDIAM (csw)	<a href="http://www.juntadeandalucia.es/medioambiente/geoinspire/servicios/srv/en/main.home">http://www.juntadeandalucia.es/medioambiente/geoinspire/servicios/srv/en/main.home</a>
REDIAM (ogc)	<a href="http://www.juntadeandalucia.es/medioambiente/rediam/ogc">http://www.juntadeandalucia.es/medioambiente/rediam/ogc</a>
REDIAM (wfs)	<a href="http://www.juntadeandalucia.es/medioambiente/mapwms/REDIAM_WFS_AI_A_Litoral?">http://www.juntadeandalucia.es/medioambiente/mapwms/REDIAM_WFS_AI_A_Litoral?</a>
REDIAM (wcs)	<a href="http://www.juntadeandalucia.es/medioambiente/mapwms/REDIAM_WCS_aquamodis_cl_a_estacional_filtrada_2000_2010?">http://www.juntadeandalucia.es/medioambiente/mapwms/REDIAM_WCS_aquamodis_cl_a_estacional_filtrada_2000_2010?</a>
Marine Plan	<a href="http://www.marineplan.es/en/subregional.html">http://www.marineplan.es/en/subregional.html</a>
<b>Basque Country's SDI</b>	<a href="http://www.geo.euskadi.eus/">http://www.geo.euskadi.eus/</a>
SRSS (inshore fishing)	<a href="http://oceandata.azti.es">http://oceandata.azti.es</a>
geo euskadi (csw)	<a href="http://www.geo.euskadi.eus/geonetwork/srv/spa/main.home?uuid=md_IDEEu_CAT_METADATOS_es">http://www.geo.euskadi.eus/geonetwork/srv/spa/main.home?uuid=md_IDEEu_CAT_METADATOS_es</a>
geo euskadi (wms)	<a href="http://www.geo.euskadi.eus/WMS_URA?request=getcapabilities">http://www.geo.euskadi.eus/WMS_URA?request=getcapabilities</a>
<b>Canary Islands SDI</b>	<a href="http://catalogo.idecanarias.es/gn/srv/en/main.home">http://catalogo.idecanarias.es/gn/srv/en/main.home</a>
shellfish harvesting closure (wms)	<a href="http://idecan2.grafcan.es/ServicioWMS/VedasMarisqueras?">http://idecan2.grafcan.es/ServicioWMS/VedasMarisqueras?</a>
sea dumping (wms)	<a href="http://idecan2.grafcan.es/ServicioWMS/Vertidos?">http://idecan2.grafcan.es/ServicioWMS/Vertidos?</a>
Gran Canaria (wms)	<a href="http://ide2.idegrancanaria.es/wms/DEUP?request=GetCapabilities&amp;service=WMS">http://ide2.idegrancanaria.es/wms/DEUP?request=GetCapabilities&amp;service=WMS</a>
Tenerife lighthouses (wms)	<a href="https://atlas.redmic.es/geoserver/tn/wms">https://atlas.redmic.es/geoserver/tn/wms</a>
Tenerife Digital Atlas	<a href="http://atlastenerife.eu/map/?lang=eng">http://atlastenerife.eu/map/?lang=eng</a>
<b>Cantabria SDI</b>	<a href="http://geoservicios.cantabria.es/inspire/rest/services">http://geoservicios.cantabria.es/inspire/rest/services</a>
<b>Catalonian SDI</b>	<a href="http://catalegidec.icgc.cat/SDIExplorer/cercaCatalog.jsp?lang=en_UK#">http://catalegidec.icgc.cat/SDIExplorer/cercaCatalog.jsp?lang=en_UK#</a>
SIGPesca (wms)	<a href="http://www.ogc.uab.es/wms/sigpesca/">http://www.ogc.uab.es/wms/sigpesca/</a>
Thalassa (wms)	<a href="http://www.opengis.uab.es/WMS/thalassa/index.htm">http://www.opengis.uab.es/WMS/thalassa/index.htm</a>
Coastal (wms)	<a href="http://www.geoportal.cat/idecwebservices/mapawms/index.jsp">http://www.geoportal.cat/idecwebservices/mapawms/index.jsp</a>
<b>Galicia SDI</b>	<a href="http://mapas.xunta.gal/directorio-de-servizos">http://mapas.xunta.gal/directorio-de-servizos</a>
river basin coast demarcation	<a href="http://visorgis.cmati.xunta.es/geoserver/dhgc/wfs?service=wfs&amp;version=1.1.0&amp;request=getcapabilities">http://visorgis.cmati.xunta.es/geoserver/dhgc/wfs?service=wfs&amp;version=1.1.0&amp;request=getcapabilities</a>
Intecmar Thredds Catalog	<a href="http://opendap.intecmar.org/thredds/catalog.xml">http://opendap.intecmar.org/thredds/catalog.xml</a>
Intecmar (csw)	<a href="http://xeocatalogo.intecmar.gal/">http://xeocatalogo.intecmar.gal/</a>
Intecmar (wms)	<a href="http://www.intecmar.org/wms-inspire/EF/wms">http://www.intecmar.org/wms-inspire/EF/wms</a>
<b>Balearic Islands SDI</b>	<a href="http://www.ideib.cat/servicios_ogc_ideib/ogc_ideib.pdf">http://www.ideib.cat/servicios_ogc_ideib/ogc_ideib.pdf</a>
nautical charts (wms)	<a href="http://ideib.caib.es/pub_ideib/public/CARTES-NAUTIQUES/MapServer/WMSServer">http://ideib.caib.es/pub_ideib/public/CARTES-NAUTIQUES/MapServer/WMSServer</a>
Menorca SDI viewer	<a href="http://ide.cime.es/visoride/">http://ide.cime.es/visoride/</a>
Majorca SDI viewer	<a href="http://www.conselldemallorca.net/sitmun/idemallorca.jsp?lang=en">http://www.conselldemallorca.net/sitmun/idemallorca.jsp?lang=en</a>
Balearic gov viewer	<a href="http://ideib.caib.es/visualitzador/visor.jsp?lang=en">http://ideib.caib.es/visualitzador/visor.jsp?lang=en</a>
<b>Murcia SDI (wms)</b>	<a href="http://iderm.imida.es/iderm/servicios/WMS.htm">http://iderm.imida.es/iderm/servicios/WMS.htm</a>
sitmurcia (cws)	<a href="http://babilonia.imida.es/geonetwork/srv/spa/search# carm_iderm_csw_catalogo_de_metadatos">http://babilonia.imida.es/geonetwork/srv/spa/search# carm_iderm_csw_catalogo_de_metadatos</a>

sitmurcia (wms)	<a href="http://loustau.imida.es/ArcGIS/services/directrices/dpotlitoraldefinitiva/MapServer/WMSServer?request=GetCapabilities&amp;service=WMS">http://loustau.imida.es/ArcGIS/services/directrices/dpotlitoraldefinitiva/MapServer/WMSServer?request=GetCapabilities&amp;service=WMS</a>
sitmurcia (viewer)	<a href="http://sitmurcia.es/visor/">http://sitmurcia.es/visor/</a>
<b>Asturias SDI (viewer)</b>	<a href="http://sitpa.cartografia.asturias.es/Geoportal/">http://sitpa.cartografia.asturias.es/Geoportal/</a>
Asturias beaches (wms)	<a href="http://sitpa.cartografia.asturias.es/wms_playas/Request.aspx?request=getcapabilities&amp;service=wms">http://sitpa.cartografia.asturias.es/wms_playas/Request.aspx?request=getcapabilities&amp;service=wms</a>
chlorophyll (wms)	<a href="http://idebos.bio.uniovi.es/cgi-bin/wmsSATELITE">http://idebos.bio.uniovi.es/cgi-bin/wmsSATELITE</a>
sardine (wms)	<a href="http://idebos.bio.uniovi.es/cgi-bin/wmsSARDINA">http://idebos.bio.uniovi.es/cgi-bin/wmsSARDINA</a>
sardine larvae (wfs)	<a href="http://idebos.bio.uniovi.es/geonetwork/srv/es/main.home">http://idebos.bio.uniovi.es/geonetwork/srv/es/main.home</a>
<b>Valencia SDI</b>	<a href="http://catalogo.icv.gva.es/geonetwork/srv/spa/catalog.search#/search?topicCat=oceans">http://catalogo.icv.gva.es/geonetwork/srv/spa/catalog.search#/search?topicCat=oceans</a>
beaches (wms)	<a href="http://cartoweb.cma.gva.es/arcgis/services/playas/MapServer/WMSServer">http://cartoweb.cma.gva.es/arcgis/services/playas/MapServer/WMSServer</a>
Valencia SDI viewer	<a href="http://terrasit.gva.es/es/ver">http://terrasit.gva.es/es/ver</a>