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<td>675680</td>
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<td><strong>Delivery Date</strong></td>
<td>November 2017</td>
</tr>
<tr>
<td><strong>Authors</strong></td>
<td>Miles Macmillan-Lawler (GRID-A), Anton Ellenbroek (FAO), Nicolas Longépé (CLS), Levi Westerveld (GRID-A), Jean Yves Lebras (CLS), Emmanuel Blondel (FAO), Paolo Fabriani (ENG)</td>
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# D7.4 Blue Environment VRE Integrated Resources: Revised Version

## PROJECT

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<td><strong>Reviewer(s)</strong></td>
<td>Gianpaolo Coro (CNR)</td>
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DISCLAIMER

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The goal of BlueBRIDGE, Building Research environments for fostering Innovation, Decision making, Governance and Education to support Blue growth, is to support capacity building in interdisciplinary research communities actively involved in increasing the scientific knowledge of the marine environment, its living resources, and its economy with the aim of providing a better ground for informed advice to competent authorities and to enlarge the spectrum of growth opportunities as addressed by the Blue Growth societal challenge.

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<tr>
<td>AQUITY</td>
<td>The CLS annotation software for geo-data</td>
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<tr>
<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<tr>
<td>EEZ</td>
<td>Economic Exclusive Zones</td>
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<tr>
<td>EO</td>
<td>Earth Observation</td>
</tr>
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<td>EODA</td>
<td>Earth Observation Data Access; the CLS tool to manage geo-data</td>
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<td>GBIF</td>
<td>Global Biodiversity Information Facility</td>
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<td>GIS</td>
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<td>GSFM</td>
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<td>IUCN</td>
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The deliverable D7.4 Blue Environment VRE Integrated Resources: Revised Version provides a description of the resources that are or will be exploited or reused in Blue Environment VREs. With the term resources, we refer to data sources, policies, guidelines, software and tools, etc. in the context of the Blue Environment VREs; in particular, as already described in deliverables D7.1 and D7.3, the Aquaculture Atlas Generation VRE and the Marine Protected Areas VRE. The document reports on the resources that have been integrated by the month M27. The mentioned VREs were described in deliverables D7.1 and D7.3, where the design and the overall goals of the VREs were specified by pointing to a set of Wiki pages. Indeed, also deliverable D7.2 and this revised version D7.4 were originally planned and implemented as a type “Other”; a living wiki page – which was in turn connected to several other wiki pages – that evolved with the development of Blue Environment resources. The rationale behind the wiki was to have flexibility in proposing new ideas, discuss potential development efforts, and report (intermediate) results. However, the overlap with the ticketing system, and the multitude of development activities, some of which stopped or completed in 2016, while other are not planned until 2018, led to fragmentation of the wiki in some parts.

Therefore, in November 2016 it was decided that a deliverable of type “Report” had to be produced to summarize the information of the wiki pages in an organized fashion. The reports D7.2 and D7.4 (as a revised version of D7.2) have been derived from the wiki pages, therefore in many sections, we report the links to the wiki pages where the reader can find more detailed (or in some cases more recent) information; the two sources are not synchronized.
EXECUTIVE SUMMARY

Work Package 7’s goal is to deliver services that serve the inventory of aquaculture farms, visualize the socio-economic performance of human activities in aquatic environments and facilitate the management of their spatial distribution in environmentally sustainable ways, consistently with the Ecosystem Approach.

This objective is met by developing two Virtual Research Environments (VREs):

- T7.1 the Aquaculture Atlas Generation (AAG) VRE;
- T7.2 the Protected Areas Impact Maps (PAIM) VRE.

Deliverable D7.4 describes the integrated resources of these VREs, focusing on the data and services that have been established, and the information related to their use.

The Use Cases related to AAG VRE refer to Aquaculture Mapping in two locations in Greece and in Indonesia. Both cases use mix data from satellites with data coming from other sources in order to obtain a comprehensive analysis of aquaculture locations that will be added to the FAO NASO maps.

The general objective of the Use Cases related to PAIM VRE is to evidence the impact of human activities on protected areas and to extract specific management indicators. For this purpose, resources are required to perform an analysis of Marine Protected Areas coverage, the biodiversity (species occurrences) within them, along with statistics about regional fisheries and aquaculture production. The proposed Use Cases were located in Caribbean and subsequently in an EU country and in Indonesia, however, the delivered product is truly global in scope!

In this Deliverable, a generic interpretation is adopted for the term resources; it can include data sources, data collections, algorithms and models, software components and services, etc. The resources of the Blue Environment VREs are integrated and exposed through the VRE infrastructure for serving particular needs. However, they do not exist in isolation, and can be used in other VREs, or in other instances of the same generic VRE, or be used outside a VRE. Of particular importance to this VRE is the use of large volumes of spatial data in an interoperable environment to extract spatial features from satellite imagery or base maps.

A set of resources has already been integrated for reaching the first milestone – the initial set-up and integration of the Blue Environment VREs - however more resources will be integrated during the VREs’ lifetime. In this deliverable we report all the integrated resources. For a detailed description of potential exploitation plans of these resources we refer to D2.5 for the sustainability plans.

This deliverable was planned to be of type “Other” and it consists of a set of wiki pages, hosted by the BlueBRIDGE wiki. The wiki version of the deliverable can be accessed at https://support.d4science.org/projects/bluebridge/wiki/Blue_Environment

For ease the reading and maintenance of the full version of the deliverable we classify resources in the following categories

- Data sources and data collections;
- Models and algorithms; e.g. to identify aquaculture cages or to extract spatial indicators;
- Software components; that contain tools that facilitate the construction and maintenance of datasets.

The integrated software components are either libraries or services that are ingested in the infrastructure and will be exploited from the VREs with other components for delivering the desired VRE functionalities.
• Documentation and user guides; to manage the above resources, as well as for the corresponding processes and functionalities.

Most of the resources in the categories above can already be integrated in the infrastructure. For each resource we provide a detailed description about how it has been integrated (or will be integrated).

Compared to deliverable D7.2, new AAPS-WebApp has been fully integrated in the AAG VRE along with aquaculture geospatial generated data. It now enables the interactive modification of output data by expert users. The PAIM VRE has received major improvements. Overall, a new design of the different services provided by this VRE enhances the users' experience. The main algorithm was reviewed as well as the overall structure of the VRE to increase its efficiency. New additional tools were developed to give more flexibility to users, and produce content-rich reports.

After the resources have been integrated they can be exploited and combined with other integrated resources. This is a key advantage of the infrastructure, because through the integration of resources, the Blue Environment VREs deliver high quality products that fulfil users’ requirements. A detailed description of the above resources, as well as more information about their integration and exploitation details (and plans) can be found at the following VRE wiki pages:

https://support.d4science.org/projects/bluebridge/wiki/T71_Aquaculture_Atlas_Generation_VRE

https://support.d4science.org/projects/bluebridge/wiki/T72_Protected_Area_Impact_Maps_VRE
1 INTRODUCTION

The deliverable D7.4 “Blue Environment VRE Integrated Resources: Revised version”, provides a detailed description of the resources that are or are going to be exploited or reused in Blue Environment VREs. With the term resources, we refer to data sources, policies, guidelines, software and tools, etc. that are going to be exploited in the Blue Environment VREs; the Aquaculture Atlas Generation VRE and the Protected Areas Impact Maps VRE.

The Blue Environment VREs provide experts with a collaborative environment for the efficient development and sharing of aquaculture and environmental maps and indicators. Given the variety of data needs and requirements and the specifics of the community, it has been decided to set up several fine-grained VREs that will share a common layer of services in main VREs, but they will implement a different subset of algorithms in dedicated VREs. The main VREs are:

- the Aquaculture Atlas Generation VRE
  https://support.d4science.org/projects/bluebridge/wiki/T71_Aquaculture_Atlas_Generation_VRE
- the Protected Area Impact Maps VRE
  https://support.d4science.org/projects/bluebridge/wiki/T72_Protected_Area_Impact_Maps_VRE

The dedicated VREs, established as Virtual online labs, each support a specific use case. The identified use cases are Aquaculture map of Greece, Aquaculture map of a section of Indonesia, Vulnerable Marine Ecosystem (VME) map of the Bahamas. Other VREs may be identified by the end project, and build on the successful features of their predecessors.

The next section describes the two VRE’s from the perspective of the integrated resources, datasets, and the data sources that are integrated as part of the Blue Environment VREs.

At the end of the subsections we report hyperlinks pointing to particular BlueBRIDGE wiki pages. These pages contain more (and in many cases more up-to-date) information about the resources.
# INTEGRATED RESOURCES

## AQUACULTURE ATLAS GENERATION VRE

### DATA SETS

#### FAO INPUT DATASETS

FAO is reviewing its NASO maps production and presentation work-flow, and until a workplan has been provided, the datasets that will be used as input for the AAPS VRE will be the NASO maps that are provided as geocoded excel files, describing farm locations as precise coordinate points, with a list of attributes for each location providing information on farm type, activity, and species cultured amongst others.

#### SPATIAL DATASETS

The spatial datasets strongly depend on the type of aquaculture structures to be identified and characterized.

The AAPS applied to fish cages detection and characterization uses very high resolution basemaps from Bing Aerial Maps, Google Earth, or Here We Go. At this stage, the decision on which of these basemaps to adopt has not been finalized as it depends on licensing issues. In particular the partnership between FAO and Google Earth Engine Outreach for the free use of satellite data is being considered. All these basemaps are accessible via WMS protocol. In the case of Bing Aerial basemap and metadata, they are accessible via Bing Maps REST services.

The AAPS applied to coastal ponds detection uses Copernicus data (Sentinel series) through gateways of the Copernicus The EU/ESA ScHub platform (https://scihub.copernicus.eu/). Data covering the Regions of Interest are automatically downloaded based on a provider-specific query. A tool to query the Sentinel data from ESA scihub or apihub, or the Greek mirror site is used. The results can be retrieved in meta4 or (geo)CSV format. This tool is not aimed at downloading the products directly: a batch downloader manager (for instance aria2 or wget) shall be used on the results of queries (see https://scihub.copernicus.eu/userguide/5APIsAndBatchScripting). This tool is using the OpenSearch API of the apihub (alternatively the scihub). In addition to recent Copernicus data, Landsat archives were also integrated so as to provide coastal ponds maps during the period 1994-1997.

#### CLS OUTPUT DATASETS

As output, a database of aquaculture features is disseminated via the VRE. This database includes:

- the contours associated to each aquaculture feature (fish cages or coastal ponds);
- include a set of attributes (following a reference ontology) with hierarchical information if relevant (for instance link between farm and fish cages);

It enables spatial query, and can be easily used by WMS/WFS.

From these requirements, 2 solutions were investigated:

- PostGIS geographic server, a spatial database extender for PostgreSQL object-relational database. It adds support for geographic objects allowing location queries to be run in SQL. This DB type enables storing a large volume of geographic data, and multiple-user access with various tools for integrated and efficient geographic processing. However, this type of database requires the setup of a dedicated server.
- Geographic files such as SpatiaLite or shapefile. These data files enable saving geographic data of medium volume, while having a large set of geographic tools. The main difference between SpatiaLite and shapefile is the ability of the former to use multiple tables which is of very high importance to track links...
between features. For instance, the use case in Greece has shown the necessity to track the links between individual fish cages and fish farms (and vice-versa).

The need to manage complex relations between objects would make the SpatiaLite preferable. Nevertheless, the BlueBRIDGE e-Infrastructur fosters the use of OGC standards and remotely accessible formats. SpatiaLite does not meet these requirements, thus shapefile format was finally chosen.

The spatialite output has been formatted to ease the integration with the editing online VRE tool adding the following attributes:

- “editors” (Text field - length 100) for storing the geo-editor username. In the CLS output, for each feature, this field should be filled with the name of the model, or any other string agreed;
- “edit_time” (datetime - ISO) for storing edition end date. In the CLS output, each feature will have this field empty (Null). When a feature will be edited, the corresponding record will have this field set to the edition date;
- “validation” (Text field - length 100) of the status during the validation process. In the CLS output, this attribute is automatically set to “New”. Then via the VRE web application any modifications on any attributes will led to the change from “New” to “Modified”. Then the user will have the possibility to validate definitely a farm. The word “Validated” will then be used.

Beyond the geometry, the following attributes have thus been defined for the cages and the farms:

As for the cages (in JSON format):
```
{
  "area":{
    "type":"Float",
    "editable":"False"
  },
  "dimension":{
    "type":"Float",
    "editable":"False"
  }
}
```

As for the farms
```
{
  "name":{
    "type":"String",
    "editable":"True"
  },
  "design":{
    "type":"List",
    "values":["Floating rigid/flexible cages","Floating flexible cages","Floating rigid cages","Semi-submersible flexible","Semi-submersible rigid", "Submersible rigid", "Unknown"],
    "editable":"True"
  },
  "edit_time":{
    "editable":"False",
    "type":"Date"
  },
  "editors ":{
    "type":"String",
    "editable":"True",
  },
  "material":{
    "editable":"True",
    "type":"String",
    "values":["Plastic", "Wood", "Steel", "Unknown"]
  },
  "feed_sys":{
```
For the Indonesia case study the following attributes have further been defined for the coastal ponds:

```json
{
    "Class": {
        "type": "String",
        "values": ["rice", "pond"],
        "editable": "True"
    },
    "edit_time": {
        "editable": "False",
        "type": "Date"
    },
    "editors": {
        "type": "String",
        "editable": "True",
    },
    "imdate_sta": {
        "editable": "False",
        "type": "Date"
    },
    "imdate_end": {
        "editable": "False",
        "type": "Date"
    },
    "Area": {
        "editable": "False",
        "type": "Float"
    },
    "validation": {
        "editable": "True",
        "type": "String",
        "values": ["New", "Modified", "Validated"],
    }
}
```
2.1.1.4 AAPS OUTPUT DATASETS FOR FAO

As of December 2017, the development of a new NASO maps infrastructure in FAO is still under review as part of the larger FAO IT architecture revision, and specific NASO requirements for the exchange of datasets with BlueBRIDGE cannot be provided. FAO fisheries department has further developed its OGC standards based Spatial Data Infrastructure, and AAPS output datasets can be stored the BlueBRIDGE infrastructure GeoNetwork to make them discoverable to FAO. BlueBRIDGE thus ensures that the AAPS output is compliant with FAO requirements.

2.1.2 SERVICES, TOOLS AND SOFTWARE

The AAPS software relies on three main tools:

- ACUITY GIS with its associated automatic algorithms
- EODA/Maestro
- AAPS Web application (AAPS-WebApp)

![Figure 1 AAPS VRE architecture](image)

GeoNetwork is a catalog application to manage spatially referenced resources. Data layers uploaded to GeoServer have metadata stored on the GeoNetwork. These metadata are used by other services of the VRE. In the web application developed for the VRE (described below) metadata for each geomorphic feature are used and integrated in the reporting system.

ACUITY GIS with its associated algorithm
The toolset developed by CLS and now interoperable with BlueBRIDGE services, further refines an existing imagery analysis tool that was developed to detect vessels from radar imagery. The toolset goes through the following steps:

- Ingestion of data (for instance from Copernicus source, upload of WMS basemap layer, upload of pre-existing aquaculture maps – FAO source);
- Selection of an Area of Interest given by pre-existing aquaculture maps. This selection is done via the drawing of a polygon by an operator (see Figure 1);
- Running the automatic algorithm of aquaculture feature detection. For the algorithm developed for the Greece use case, round and square fish cages are to be detected (see Figure 2).

![Figure 2 Select an area of interest to detect farms](image)

![Figure 3 result of automated detection](image)

- After the automated detection of features, a manual phase of correction, confirmation and validation follows. The user can draw more precise boundaries, change the sizes, add manually detected areas, describe cage typology, and group cages by farm. The tool can compute total farm size and count number of cages.

![Figure 4 Manual editing of detected features](image)
Once ready with describing the aquaculture features in an image, the results can be stored using the aforementioned ontology, i.e. as reference vocabulary in the form of a formalized description of the identified features. This includes the actual or supposed dates of when the image was taken, and depending on data availability, this can result in a time series of aquaculture development.

Figure 5 Export of detected features using an ontology

EODA/Maestro

In the world of the geospatial data management and dissemination, international groups are currently working on specifications and implementations of interoperable interfaces\(^1\), especially the Open Geospatial Consortium (OGC\(^2\)) and International Standard Organization (ISO\(^3\)). The CLS EODA platform uses notably OGC and ISO standards, which are now internationally recognized. It ensures the cost-effective and efficient communication involving the geospatial products between EODA platform and VRE infrastructure. Meanwhile, data volumes are particularly important for Earth Observation imageries, and should not be duplicated unnecessarily. As an illustration, one single Sentinel-1 image can be in the order of 1GB. That is why only useful EO data covering the AOI and of interest for the use case will be downloaded from the EU (see Subsection 2.1.1.2). This is handled by EODA system which has already the capability to query, ingest, and made available for visualisation EO data.

The standards used to implement the EODA web GIS include notably:

- The format of the catalogue metadata: ISO 19115 specifications, and its implementation ISO 19139 XML schema
- The inventory and viewing service for the EO and aquaculture features datasets: OGC Web Map Service (WMS)

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1 Interoperability is the capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units.

2 OGC: Open Geospatial Consortium. The Open Geospatial Consortium, Inc. (OGC) is a non-profit membership organisation to address interoperability among systems that process geo-referenced data, and between these systems and mainstream computing systems. OGC has about two hundred and twenty members from public and private organisations around the World.

3 ISO: International Standard Organization ISO/TC 211 is one of a number of Technical Committees enveloped within the International Standards’ Organisation (ISO), and was formed for the development of standardisation in the field of digital Geographic Information. TC 211 aims “to establish a structured set of standards for information concerning objects or phenomena that are directly or indirectly associated with a location relative to the earth. These standards may specify, for Geographic Information, methods, tools and services for data management (including definition and description), acquiring, processing, analysing, accessing, presenting and transferring such data in digital/electronic form between different users, systems and locations”.

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As the VRE infrastructure will broadcast the WFS layer associated to the detected aquaculture features (provided by ACUITY), EODA broadcasts their associated Copernicus images and these will be visible in the AAPS VRE too.

**D4Science Copernicus Service**

D4Science, the e-Infrastructure underlying BlueBRIDGE, provides biotic and abiotic geospatial data from the Copernicus Marine Environment Monitoring Service (CMEMS)\(^4\) that, only for the Mediterranean Region, includes about 150 datasets. CMEMS provides facilities to programmatically browse and download their hosted data. Besides WMS and FTP access, a REST APIs exposed by a number of “Motu”\(^5\) web services is also available. Motu is a high-efficiency service that manages the heterogeneity between the data of different CMEMS providers. In particular, Motu handles, extracts and transforms oceanographic huge volumes of data without performance collapse. Interaction with Motu is supported mainly through an open-source Python client\(^6\), which enables extracting and downloading data through command line. This client, however, shows a couple of limitations that do not immediately fit VRE needs: it does not provide browsing capabilities, meaning that one should identify the dataset, as well as other request parameters (e.g. bounding box, time frame) either by browsing the website or interacting directly with the Motu server REST API. Furthermore, the size of the downloaded dataset is typically limited by Motu servers (currently about 1GB); although it’s possible to submit multiple requests to a server, the client does not provide support for merging data afterwards.

D4Science facilitates the access to CMEMS data with a Dataset Aggregator Facility to allow users to browse and select datasets, configure the area of interest, specify a number of basic post-processing (e.g. average) and have data published and regularly updated in the D4Science THREDDS Data Server and indexed in GeoNetwork. Products are then made available to the Protected Area Impact Maps VRE, as well as in other interested VREs. The adopted approach simplifies the access to CMEMS metadata and datasets, overcoming some of the limitations of the Motu server and client and provides users with an easy-to-use interface to manage synchronized datasets. Up to now, a set of 307 products have been extracted from CMEMS (and other EO providers) and made available to the VRE, which includes global and regional distributions of biotic and abiotic environmental features. The full list is available as an excel file in the VRE\(^7\) and can be browsed using the GeoExplorer web application, available in the VRE. These products are also available to all the applications running in the VRE.

**AAPS-WebApp**

The AAPS-WebApp is a web interface available in the VRE developed by CLS and integrated through WP9. It has been developed using REACT 15.0.0, REACT-REDUX 5.0.1, REACT-ROUTER 3.0.0, REDUX 3.6.0 and REACTJS. These libraries enable a dynamic and fluid navigation of the Web site built around one single page. Interfacing with available “GeoServers”, open source services that host and share geospatial data, has been carried out:

- Geospatial aquaculture features are stored and broadcasted under the WFS standard through a GeoServer instance installed and hosted by D4Science

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\(^5\) [https://github.com/clstoulouse/motu](https://github.com/clstoulouse/motu)

\(^6\) [https://github.com/clstoulouse/motu-client-python](https://github.com/clstoulouse/motu-client-python)

\(^7\) [http://data.d4science.org/QUtqOE5PNnRKSWpIdjJVR2gxMkRpUS9jSVBycFNKSTRHbWJQNSfIS0N6Yz0](http://data.d4science.org/QUtqOE5PNnRKSWpIdjJVR2gxMkRpUS9jSVBycFNKSTRHbWJQNSfIS0N6Yz0)
• Copernicus images are broadcasted via EODA/Maestro through WMS.

Open Layer 4.1.1 libraries have been used to display these WFS/WMS. Most of the spatial data visualized and analyzed in the Protected Area Impact Maps VRE are stored on a GeoServer instance.

The AAPS Web-App is based on modules and components that are easy to update. Add-ons can be easily added without questioning the integrity of the WebApp. In the following, the internal structure of the Web-App is outlined:

```
├── bin     # Build/Start scripts
├── config # Project and build configurations
├── data    # Files used to set up data of the project
├── public  # Static public assets (not imported anywhere in source code)
├── server  # Express application that provides webpack middleware
│   └── main.js   # Server application entry point
└── src      # Application source code
    ├── index.html # Main HTML page container for app
    ├── main.js    # Application bootstrap and rendering
    │    ├── components # Global Reusable Presentational Components
    │    ├── containers # Global Reusable Container Components
    │    └── layouts    # Components that dictate major page structure
    │         └── CoreLayout.js    # CoreLayout which receives children for each route
    │         └── CoreLayout.scss  # Styles related to the CoreLayout
    │         └── index.js         # Main file for layout
    ├── routes    # Main route definitions and async split points
    │    └── index.js     # Route definitions and async split points
    │         └── modules   # Collections of reducers/constants/actions
    │         └── components # Presentational React Components
    │             └── routes ** # Fractal sub-routes (** optional)
    └── store     # Redux-specific pieces
        └── createStore.js # Create and instrument redux store
        └── reducers.js    # Reducer registry and injection
    └── styles      # Application-wide styles (generally settings)
```

The configuration of the AAPS WebApp is done via the configuration files in the folder `~/data/`. In particular:

• `bluebridge-usecases.json`: Configuration file for the different use cases to display in the application;
• cageDictionary.json: Configuration file that specifies fields of cages data from the GeoServer;
• farmDictionary.json: Configuration file that specifies fields of farms data from the GeoServer;
• sarGreece.csv: Configuration file with Greece SAR products to be displayed in the application. It is used by EODA/Maestro GeoServer to display the proper Copernicus images;
• sarIndonesia.csv: Configuration file with Indonesia SAR products that we want to display in the application. It is then used by EODA/Maestro GeoServer to display the proper Copernicus images.

This AAPS WebApp toolset developed by CLS complements a geospatial aquaculture product generated via the ACUITY platform. At this stage, it should be mentioned that only the attributes associated to each detected farm can be modified here. No modification of the contour of each fish cage is allowed.

The AAPS WebApp tool procedure acts as follows to assess and identify aquaculture farms:

• The user connects to the platform via its AAPS token. Two levels of users are identified depending upon the profile of the users. If the profile contains a “Data-Manager” role, then the logged user is a “super user” with editing capabilities in the WebApp. If not, it can only browse the data. To retrieve username and role, the D4Science SDI web-service is activated based on VRE token.
• Depending upon zoom level, the farms to be validated among all the detected farms shows up via a “cluster”. When the zoom is sufficiently high, the fish cages appear.
The user can select a farm and then edit its attributes. The same model is used for the production of the layers and for their validation, i.e. the ontology previously mentioned is available via a code-list when relevant. At this stage, the “Data Manager” can either:

- update the fish farm: the layer in the “staging” environment is updated via T-WFS. In this case, the AAPS web application changes the colors of the updated farm from red to orange.
- validate the fish farm: the layer in the public environment is enriched with this new validated farm. The update of this farm is then no longer possible. In this case, the AAPS application changes the colors of the updated farm from red/orange to green. A validation process is accompanied by a publication of the validated farm in the BlueBRIDGE GeoNetwork catalogue. A set of metadata are automatically created.

In all the cases, when the “Data Manager” user updates or validates a farm, its username (retrieved from the D4Science SDI) along with the timestamp of this action is included in the attribute of the modified/validated farms.

Figure 6 Fish farms to be validated by the Data Manager user for different levels of zoom (displayed from coarser to higher resolution)
For standard users (i.e. those whose profile is not of “Data manager” role), only the visualisation of layers within the “public” environment is available (see figures below). The link to the associated GeoNetwork web page is provided.

Figure 7 Modification/validation process for one farm
Figure 8 AAPS WebApp for simple user
Figure 9 Publication of validated farms metadata in the GeoNetwork catalogue, displayed through the D4Science GeoNetwork web page

For the Indonesian study case, static visualization of available data has been implemented. There is no “Super User” with editing capabilities. Instead, statistical analysis could be possibly integrated. For instance, it could use the algorithms integrated for the MPA VRE.

Figure 10 Visualisation of layers of coastal ponds detection in Sulawesi, Indonesia for two periods: pink from 1994-1997, and blue from 2014-2017. Yellow colour indicates rice paddy fields detected from time-series analysis of Sentinel-1 images

In summary, the AAPS Web application re-uses parts of the MPA-Map viewer; a prime example of infrastructure tools re-use. The tool visualizes the CLS output, allows for editing of features, and generates output as FAO NASO Maps. It also allows reporting the clustering of these features in farms or production units, relative to a target region of interest (e.g. a Province), and computing overall statistics. A first working version of the web interface has been integrated with the AAPS VRE in November 2017. After a review and validation process of the interface and algorithm by the BlueBRIDGE users, changes and additional capacities may be added until the project closure.
2.1.3 MODELS/ALGORITHMS

A specific model for the fish cages/farms in Greece has been applied. It is described above.

Beyond the automatic algorithm for fish cage detection based on VHR optical images, but hosted within ACUITY toolbox, the proximity algorithm has been prototyped by FAO, enabling to find the closest NASO farms to a given farm of the staging layer.

A model has been developed for Indonesia as well. The algorithm to generate such layers “coastal pond / rice paddy field” is based on a set of tools hosted within ACUITY toolbox:

- Normalized Water Detection Index calculated for each multispectral optical image (Sentinel-2 and Landsat)
- Computation of averaged NDWI based on series of multispectral images (two periods selected here: 94-97 and 2014-2017), and threshold-based algorithm to detect permanent water bodies.
- Stacking of Sentinel-1 images based on accurate geo-referencement and geocoding in a reference projection
- SAR image filtering based on multi-temporal Speckle filter
- Classification algorithm based on time-series analysis of radar images to discriminate coastal ponds from rice paddy fields
- Merging results from NDWI and SAR-based processes
- Creating vector information

2.1.4 USER GUIDES

The VRE incorporates user guidance through help features. Since the tool will mainly be used by geospatial data experts, advanced user interactions are not required.

This VRE shall be activated by specific request via the VRE platform. Internal modules such as the annotation ACUITY platform are to be run by CLS. As such, no user guide has been produced at this stage. However, online demonstration might be made available for VRE users.

For what concerns the AAPS-WebApp, online demonstration and webinar are planned for the VRE users.

2.1.5 USAGE/LICENSING

The usage of these resources and toolboxes is illustrated in Figure 1.

Detection algorithms are implemented in ACUITY toolbox. ACUITY is only used by CLS analysts to generate the new value-added aquaculture products stored in the AAPS VRE.

During the project, registered external users and internal users (all project partners) have then access to the new aquaculture products and ancillary information. These data fall under the BlueBRIDGE Terms of Use and Licenses.

At the end of the project CLS and D4Science will attempt to sign a MoU for the exploitation of this service. This will rely at minima on the following requirements:

- Minimum duration of D4Science, EODA/MAESTRO availability to broadcast Copernicus images and Earth Observation Very High Resolution licence grant.
- Conditions of usage of CLS resources (e.g. algorithms and ACUITY toolbox, analyst work) to generate new or refined aquaculture products.
All other data and tooling come fall under the BlueBRIDGE Terms of Use and Licenses.

## 2.2 PROTECTED AREAS IMPACT MAPS

### 2.2.1 DATA SETS

The following data sets have been incorporated into the Protected Area Impact Maps VRE.

<table>
<thead>
<tr>
<th>Data Set</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Exclusive Zones Boundaries. Version 9</td>
<td>Global scale spatial dataset of the Exclusive Economic Zones. It includes disputed territories. After download, the dataset was modified in ArcGIS with the addition of a polygon for international waters beyond the EEZ. The latest version (v.9) of the EEZ dataset has been integrated in the VRE. It is used both by the graphical interface as well as the intersect algorithm for this VRE.</td>
</tr>
<tr>
<td>Marine Ecoregions and Pelagic Provinces of the World (MEOW, PPOW). January 2016.</td>
<td>This dataset combines two separately published datasets: the “Marine Ecoregions Of the World” (MEOW; 2007) and the “Pelagic Provinces Of the World” (PPOW; 2012). The MEOW dataset shows a biogeographic classification of the world’s coastal and continental shelf waters. The PPOW dataset shows a biogeographic classification of the surface pelagic (i.e. epipelagic) waters of the world’s oceans. This dataset has been integrated in the VRE. It is used both by the graphical user interface and the intersect algorithm.</td>
</tr>
<tr>
<td>Marine Ecoregions and Pelagic Provinces of the World (MEOW, PPOW). January 2016.</td>
<td>We are only keeping the MEOW dataset as a reporting layer for ecoregions.</td>
</tr>
</tbody>
</table>

After testing, due to the complexity of the integrated MEOW and PPOW data layers geometry, we decided to only keep the MEOW data in the PAIM VRE as a zone layer for an analysis. The MEOW dataset ([https://www.worldwildlife.org/publications/marine-ecoregions-of-the-world-a-bioregionalization-of-coastal-and-shelf-areas](https://www.worldwildlife.org/publications/marine-ecoregions-of-the-world-a-bioregionalization-of-coastal-and-shelf-areas)) covers almost all MPAs.


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D7.4 Blue Environment VRE Integrated Resources: Revised Version

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<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>As before, the WDPA is preprocessed by JRC (Joint Research Center). A link to the processing methodology is available here: <a href="https://dopa.wikispaces.com/WDPA+protected+Area+boundaries">https://dopa.wikispaces.com/WDPA+protected+Area+boundaries</a></td>
</tr>
<tr>
<td>Global scale spatial dataset of protected areas managed by UNEP-WCMC. After the data is provided to us by JRC, the dataset is modified in ArcGIS before used in the VRE. Modifications include deleting all protected areas that are not marine using information in the attribute table (MARINE = 0). The data is then intersected with the EEZ datalayer creating one output and with the ECOREGION datalayer creating another output. The intersect step removes any segment of the marine protected areas that are outside of the EEZ or the ECOREGION limits (e.g. some protected areas cover both marine and terrestrial ground). The two outputs are finally dissolved so that separate polygons of a same marine protected area in a unique EEZ or ECOREGION are joined together.</td>
</tr>
<tr>
<td>The November 2016 version of the WDPA has been integrated in the VRE. It is used in the reporting section of the graphical user interface and is a key dataset used by the intersect algorithm. A new version of the dataset (from January 2017) and prepared by JRC will be integrated in the VRE by the end of March 2017. In March 2017 the data was updated to the January 2017 version of the WDPA data. In November 2017, the data was updated to the October 2017 version of the WDPA. Early next year, we will update the WDPA data one more time to the January 2018 version.</td>
</tr>
<tr>
<td>Data Source</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Global Seafloor Geomorphic Data. March 2014. Accessed at:</td>
</tr>
<tr>
<td><a href="http://www.bluehabitats.org/?page_id=58">http://www.bluehabitats.org/?page_id=58</a></td>
</tr>
<tr>
<td>Global distribution of Seagrass. Version 4.0. 2016. Accessed at:</td>
</tr>
<tr>
<td><a href="http://data.unep-wcmc.org/datasets/7">http://data.unep-wcmc.org/datasets/7</a></td>
</tr>
<tr>
<td>Dataset Description</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td>Global Distribution of Mangroves USGS version</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Dataset Description</th>
<th>Source (URL)</th>
<th>Integration Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Distribution of Coral Reefs.</td>
<td>This dataset shows the global distribution of coral reefs in tropical and subtropical regions. This dataset was compiled from a number of sources by UNEP World Conservation Monitoring Centre (UNEP-WCMC) and the WorldFish Centre, in collaboration with WRI (World Resources Institute) and TNC (The Nature Conservancy). (Integration in the VRE in progress)</td>
<td>This dataset has been uploaded to the geoserver. Because of its complexity, it has not yet been integrated in the intersect algorithm and graphical user interface. GRID-Arendal is working with FAO to find the best solution to fully integrate this dataset in the VRE and its services.</td>
</tr>
</tbody>
</table>

This dataset can now be analyzed by the PAIM VRE algorithm through the Data Miner. However, we have not yet included it in the MPA Reporting interface for visualization. The complexity of the geometry of the layer means displaying at a global scale is very slow. A generalized version for display purposes is developed.

2.2.2 SERVICES, TOOLS AND SOFTWARE

The following are the services, tools and software used by and incorporated into the Protected Area Impact Maps (PAIM) VRE.

VRE basic portlets

In the BlueBRIDGE project, each VRE comes with a standard set of portlets that are kept or discarded based on the needs for a specific VRE. We have reviewed and changed the order and the specific portlets utilized by the PAIM VRE (Figure 12). Besides the two portlets that were custom built and designed specifically for the PAIM VRE (‘About PAIM VRE’ and ‘MPA Reporting’), the PAIM VRE also utilizes the following portlets:

- The ‘Members’ portlet lets users see who else is using the PAIM VRE.
- The ‘Social Networking’ portlet is a space where users can update each other on data, algorithms or other information as well as share experience and any other thoughts about PAIM.
- ‘Data Miner’ is a different portlet where users can run PAIM algorithms. It is a more basic version of the ‘MPA Reporting’ portlet.
- ‘Data Catalogue’ is a portlet where users can view and access all the data hosted by BlueBRIDGE.
- ‘Rstudio’ is an online instance of the software where users can run PAIM or other algorithms as needed using cloud computing. We have published the R scripts of the PAIM VRE on github and these can easily be downloaded, edited and run in the Rstudio portlet in the VRE. Link to the github account: https://github.com/grid-arendal
Figure 12 screenshot of the landing page for the PAIM VRE. The different portlets of this VRE are shown in the top bar. Administrators for this VRE have two extra portlets ‘Administration’ to manage users and ‘SAI’ to develop and deploy algorithms in the VRE.

**GeoServer** is open source server installed on D4Science to host and share geospatial data. All the spatial data visualized and analyzed in the Protected Area Impact Maps VRE is stored on the GeoServer. See previous section (2.2.1 Data Sets) which outlines the specific spatial datasets used by this VRE. In the future, we may decide to access the UNEP WCMC data for mangroves, seagrass and coral reefs directly from their infrastructure as a WFS. A direct access to their data would ensure that our service is more sustainable as it would use the most up-to-date data, and any changes to the original data will directly be reflected in the outputs the VRE provides. A WFS is not yet available, but discussions with UNEP WCMC regarding this specific request are in motion.

Because the data from UNEP-WCMC has a complex and at times faulty geometry and topology, we are not directly using WMS access into the PAIM VRE environment. Instead, we optimize a copy of the data before integrating it in the PAIM VRE for analysis.

Moreover, we have created 2 additional GeoServers that host the same data than the original one. The heap memory of each GeoServers was also increased. The increased heap memory and number of GeoServer instances increases the efficiency with which layers are fetched for visual display and analysis.

**GeoNetwork** is a catalog application to manage spatially referenced resources. Data layers uploaded to GeoServer have metadata stored on the GeoNetwork. This metadata is used by other elements of the VRE. In the web-app developed for the VRE (described below) for example, metadata for each geomorphic feature is integrated in the reporting section.

The **MPA-Map** is a web interface available in the VRE that is developed by GRID-Arendal and FAO. It is a tool to visualize marine features such as geomorphic features and to report on the presence of these features in marine managed areas (e.g. Marine Protected Areas) relative to a target region of interest (e.g. Exclusive Economic Zone). The web application has three main features. A **Data explorer map** (Figure 13) which allows users to visualize data used by the algorithm and select a target region of interest on which to run the algorithm. A **Results** (Figure 14) page that includes tables and charts displaying data results from the algorithm. A **Report** (Figure 15) page that shows, in details, the spatial distribution of features relative to each marine managed area in the target region of analysis. A first working version of the web interface
is in its final stage of development and will be integrated in the Protected Area Impact Map VRE when ready. After a review process of the interface and algorithm by users, changes and additional capacities will be added (e.g. user capacity to upload own unique or network of marine managed areas to report on).

Before the public launch of the PAIM VRE in early November, feedback from individuals familiar with the user community of the PAIM VRE provided feedback on the interface. Each comment was reviewed and addressed when possible. We will keep engaging users and collecting feedback which will help direct the further development of services and tools available in the PAIM VRE.

Figure 13 Screen capture of the Map Explorer in the MPA-Map web interface (in development). Here, the user can view features included in the algorithm, select an EEZ or ECOREGION, and Run the Analysis.

Figure 14 Screen capture of the Results section in the MPA-Map web interface (in development). Here, the user can visualize results from the algorithm after an analysis is performed (Figure 14). At the top, a searchable table reports on the area in km² of features in Marine Protected Areas. The table can be toggled to % to show the percent of features in an MPA relative to the total area of the feature in the target region. At the bottom, a chart compares the area of features in the target region versus the area of features in all MPAs in the target region.
After selecting an MPA in the Results page, a Report section is compiled which integrates information on the features present in the MPA with maps showing their spatial distribution in the MPA. This section will also show metadata information for each feature.

The MPA-Map (renamed MPA Reporting) web interface has undergone significant changes from the time when the first version of this report (D7.2) was written. Regarding the overall interface, it is now fully integrated in the VRE which means that it can be accessed as a portlet in the VRE for any user that is signed in on the infrastructure. Changes regarding each page (Data Explorer, Results, and Report) are outlined below:

1. **Data Explorer**: A new dialogue welcome box was added to the Data Explorer page which briefly explains how to use the MPA Reporting interface. The basemap on which the layers are displayed was changed as the original basemap was not loading correctly. Users now have a choice between the ESRI World Imagery and the ESRI Countries basemaps. The MPAs used in the analysis were also added as a layer which can be turned on and off in the Data Explorer. This gives users an overview of MPAs’ spatial distribution before running an analysis. The order of the Geomorphic Features was changed for better display on the map (Figure 16).
2. **Results:** Some simple changes were made to the Results page. Most notably, in the bar graph, the values were originally shown in m$^2$ rather than km$^2$, this was now changed so that all values shown in the interface are in km$^2$. The colors of the graph bar was also changed. In the Results page, users can now also download to their PC the .CSV file with the original data computed in an analysis and a PDF static report document which integrates text as well as the tables, charts and maps produced by the MPA Reporting interface. When these files are saved to a user PC, a copy is also saved to the user’s workspace in the VRE infrastructure.

3. **Report:** The design and content of the MPA specific report page was also modified. As per user request, we have added to the top of the Report page the specific attribute information for each MPA. This includes information on an MPAs’: WDPA ID, Designation, Designation Type, IUCN Status, Status, Year, Governance, and Managing authority. The name of the MPA is now also a hyperlink,
which links to the website of that MPA on the Protected Planet website (https://www.protectedplanet.net/). Information on the sources for the data was added and includes links to documentation explaining how the original data was modified (for the WDPA data for example). The general design was also changed to give more room to the map of the selected MPA and the intersected data. Users can now select which geomorphic feature is shown on the map. The Abstract and Reference information for the intersected feature shown is automatically updated in the left hand side panel.

Figure 18 Screen capture of the new Report page in the MPA Reporting web interface.

### 2.2.3 MODELS/ALGORITHMS

#### 2.2.3.1 INTERSECTION ALGORITHM

MPA-Map web interface. The algorithm takes an ID input value defining either an EEZ or Ecoregion of interest. The algorithm uses this information to fetch geospatial data of features and protected areas located in the target region, and intersects features with protected areas in this region. It then compiles a report in tabular format with information on the area of each feature in each protected areas and in the target region as a whole. If used in DataMiner, the output from the algorithm is a .csv file with a list of MPAs and the area in m² of features reported (e.g. geomorphic features) in each MPA. The area in m² of features in the target region (an EEZ or ECOREGION) and in all the MPAs in the target region is also included.

The algorithm uses the RfigisGeo package developed by Emmanuel Blondel for FAO to compute the intersections and calculate area.

Since D7.2 was written, the PAIM VRE primary script (Mpa Intersect V2) used by the MPA Reporting portlet was optimized. A new script (Mpa Intersect V3) was also developed and is available to users through the Data Miner of this VRE.

Regarding the optimization of Mpa Intersect V2, the following changes were made:
1. To increase the efficiency with which data is fetched, the bounding box of the selected Zone Layer (EEZ or ECOREGION) is retrieved by the algorithm and used as a parameter to fetch other data. Data outside of the bounding box is automatically disregarded and not fetched.

2. Part of our output is the total area of ‘All MPAs’ as well as the intersected values of ‘All MPAs’ with each selected geomorphic feature. In the initial script, this value was calculated by summing up the intersected value of all unique MPAs in a Zone Layer. However, we found that in some cases MPAs overlapped which meant the summed values of All MPAs was much larger than the actual coverage as some areas were counted twice or more. In the script, we now dissolve the MPA layer and use the dissolved output to generate the ‘All MPAs’ value.

3. We have also modified our algorithm so that it can now run in parallel. Different intersections run simultaneously on different machines decreasing processing time. The outputs from the intersections are aggregated after the intersection calculations are completed.

4. We migrated the current algorithm environment to a different more powerful cloud cluster. The new cloud cluster environment plays a significant role in reducing the overall computation time during analysis.

As mentioned in section 2.2.2, there is a need from the user community to be able to analyze their own MPAs and data within the PAIM VRE. To meet those needs, a second algorithm (Mpa Intersect V3) was developed. This algorithm lets users upload their own MPA data to generate a report. This algorithm is useful for users that are planning new MPA networks and want to know how well these cover different important marine features. Currently, users have to use the Data Miner to upload a shapefile of their own MPA(s) and select which features to be included in the analysis. In Data Miner, users can select any number of the 20 geomorphic features from the PAIM VRE. Currently seagrass, mangroves or coral reefs are only available in Data Miner (Figure 19).

Figure 19 Screen shot of the Mpa Intersect V3 algorithm in the Data Miner. Users can either select a Zone Layer (EEZ or ECOREGION) or they can upload their own MPA shapefile as a .zip file (MPA_Shapefile_url) and select features to be included in the analysis (Selected_Data_Feature).
User Guides are yet to be developed for the Protected Area Impact Maps VRE. These guides will be developed in the first quarter of 2017.

As part of the public launch of the PAIM VRE that took place on November 8th, 2017, we developed an interactive user guide to the PAIM VRE which also acts as the landing page for new users that enter the PAIM VRE. It is available in the ‘About PAIM VRE’ portlet.

The introductory guide explains the context in which the PAIM VRE was built (what questions does it answer and which community does it serve) and runs users through the data and algorithms used by the PAIM VRE. It then explains how to use the MPA Reporting Portlet to visualize, analyze and report on the level of protection of different important marine features in MPAs around the world. The guide includes text with hyperlinks where relevant, maps, videos and pictures. The guide can also be accessed at this link:

https://arcg.is/emHiu

Figure 20 Screen capture of the introductory guide integrated as a portlet ‘About PAIM VRE’ in the PAIM VRE interface.
On November 9th, GRID-Arendal with the support of TRUST-IT also hosted a webinar that covered the context in which the PAIM VRE was developed, the technical aspects of the VRE and backend infrastructure, and how to use the different portlets in the VRE. The webinar was recorded and is also available on the VRE in the ‘Social Networking’ portlet. It also acts as a different User Guide.

A .PDF document outlining how to use the algorithms through DataMiner was also written and is available at this link: www.goo.gl/TiDhjg

### 2.2.5 USAGE/LICENSING

The following table contains the usage and licencing for data incorporated into the Protected Area Impact Maps VRE.
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REFERENCES

[19] gCube wiki: https://wiki.gcube-system.org/gcube/About_gCube