QUIETMED – Joint programme on noise (D11) for the implementation of the Second Cycle of the MSFD in the Mediterranean Sea.

Deliverable

D4.1 International impulsive noise register for the Mediterranean basin

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Document Number: QUIETMED - D4.1

Delivery date: 5th December 2018

Call: DG ENV/MSFD Second Cycle/2016

Grant Agreement: No. 11.0661/2016/748066/SUB/ENV.C2

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3	Universitat Politècnica de València	UPV	Spain
4	Service Hydrographique et Océanographique de la Marine	SHOM	France
5	Ispra Instituto Superiore per la Protezione e la Ricerca Ambientale	ISPRA	Italy
6	Inštitut za vode Republike Slovenije/Institute for water of the Republic of Slovenia	IZVRS	Slovenia
7	Permanent Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area	ACCOBAMS	Monaco
8	The Conservation Biology Research Group, the University of Malta	UoM	Malta
9	Institute of Oceanography and Fisheries	IOF	Croatia
10	Foundation for Research and Technology - Hellas	FORTH	Greece

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Acknowledgements

The impulsive noise register has been developed for the Mediterranean Sea following the work done by the International Council for the Exploration of the Sea (ICES) in the implementation of the register for the OSPAR and HELCOM region. Our thanks to Neil Holdsworth and Carlos Pinto from ICES for the support provided.

Abstract

This document is the Deliverable "D4.1 International impulsive noise register for the Mediterranean basin." of the QUIETMED project funded by the DG Environment of the European Commission within the call "DG ENV/MSFD Second Cycle/2016". The QUIETMED project aims to enhance cooperation among Member States (MS) in the Mediterranean Sea to implement the Second Cycle of the Marine Directive and in particular to assist them in the preparation of their MSFD reports by 2018.

This document describes the web tool (Impulsive Noise Register in the Mediterranean Sea, INR-MED) built during this project to host data on underwater impulsive noise sources and to display indicators related to Descriptor 11 Criterion 1 (D11C1: *Anthropogenic impulsive sound in water*) at the regional scale.

The INR-MED comes after the development by the International Council for the Exploration of the Sea (ICES) of the international noise register for the North-east Atlantic area (including the North Sea, the Celtic Sea, and the English Channel) and the Baltic Sea, i.e. the areas covered by the Regional Seas Conventions OSPAR and HELCOM, and has the same global objective. It is indeed conceived to support ACCOBAMS in producing information that will feed regional assessments on underwater noise pollution, and in reporting by Contracting Parties which are also members of the European Union to MSFD D11C1, and by Contracting Parties which are not membres of EU to the Ecological Objective 11 (Low and mid-frequency impulsive noise) of the Ecosystem Approach process (EcAp-EO11) led by the Barcelona Convention.

The tool described in this document covers important objectives of the Memorandum of Understanding between the Secretariats of ACCOBAMS and UNEP/MAP on topics related to underwater noise monitoring and assessment, and relevant provisions of ACCOBAMS Resolutions dealing with the management of the impact of anthropogenic noise on cetaceans (though limited to the Mediterranean Sea). The INR-MED was developed in line with Commission Decision 2017/848 and following guidance documents from TG-Noise. The conception is based on the first demonstration tool developed by ACCOBAMS in 2016 for the Mediterranean Sea and the Black Sea and took advantage of the work done by OSPAR, HELCOM and ICES on the same topic.

Modern web technologies were employed to build the database and the functions of data reporting by countries. The INR-MED includes functions for disseminating information through cartographic means and data download services. Procedure for countries for reporting data are described, and methods selected for calculating and displaying indicators are presented.

Finally, this document addresses the topic of long term management of the regional register and presents perspectives for future developments. After the completion of QUIETMED, it is expected that this register will be hosted and be available through the ACCOBAMS's website.

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List of Abbreviations

CTN	Centro Tecnológico Naval y del Mar
IEO	Instituto Español de Oceanografía
UPV	Universitat Politècnica de València
SHOM	Service Hydrographique et Océanographique de la Marine
ISPRA	Ispra Instituto Superiore per la Protezione e la Ricerca Ambientale
IZVRS	Inštitut za vode Republike Slovenije
ACCOBAMS	Permanent Secretariat of the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area
UoM	The Conservation Biology Research Group, the University of Malta
IOF	Institute of Oceanography and Fisheries
FORTH	Foundation for Research and Technology – Hellas
MSFD	Marine Strategy Framework Directive
ICES	International Council for the Exploration of the Sea
INR-MED	Impulsive noise register of the Mediterranean Region

1 Introduction.

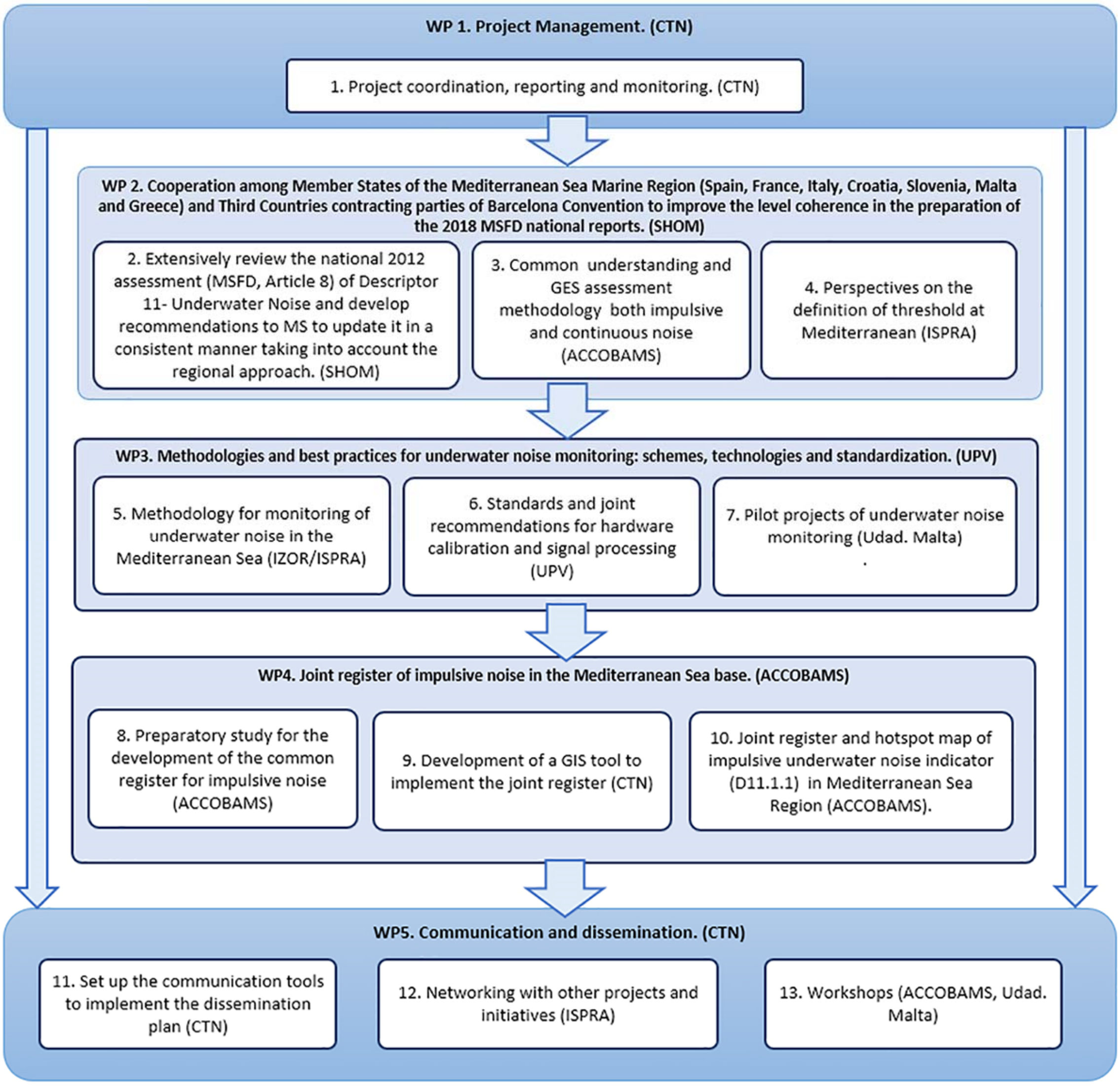
The QUITMED Project is funded by DG Environment of the European Commission within the call "DG ENV/MSFD Second Cycle/2016". This call funds the next phase of MSFD implementation, in particular to achieve regionally coherent, coordinated and consistent updates of the determinations of GES, initial assessments and sets of environmental targets by July 2018, in accordance with Article 17(2a and 2b), Article 5(2) and Article 3(5) of the Marine Strategy Framework Directive (2008/56/EC).

The QUIETMED project aims at enhancing cooperation among Member States (MS) in the Mediterranean Sea to implement the Second Cycle of the Marine Directive and in particular to assist them in the preparation of their MSFD reports by 2018 through: i) promoting a common approach at Mediterranean level to update GES and Environmental targets related to Descriptor 11 in each MS marine strategies ii) development of methodological aspects for the implementation of ambient noise monitoring programs (indicator 11.2.1) iii) development of a joint monitoring programme of impulsive noise (Indicator 11.1.1) based on a common register, including gathering and processing of available data on underwater noise. The Project has the following specific objectives:

- ✓ Achieve a common understanding and GES assessment (MSFD, Article 9) methodology (both impulsive and continuous noise) in the Mediterranean Sea.
- ✓ Develop a set of recommendations to the MSFD competent authorities for review of the national assessment made in 2012 (MSFD, Article 8) and the environmental targets (MSFD, Article 10) of Descriptor 11- Underwater Noise in a consistent manner taking into account the Mediterranean Sea Region approach.
- ✓ Develop a common approach to the definition of threshold at MED level (in link with TG Noise future work and revised decision requirements) and impact indicators.
- ✓ Coordinate with the Regional Sea Convention (the Barcelona Convention) to ensure the consistency of the project with the implementation of the EcAp process
- ✓ Promote and facilitate the coordination of underwater noise monitoring at the Mediteranean Sea level with third countries of the region (MSFD Article 6), in particular through building capacities of non-EU Countries and taking advantage of the ACCOBAMS-UNEP/MAP cooperation related to the implementation of the Ecosystem Approach Process (EcAp process) on underwater noise monitoring.
- ✓ Recommend methodology for assessments of noise indicators in the Mediterranean Sea basin taking into account the criteria and methodological standards defined for Descriptor11 (Decision 2010/477/EU, its revision and Monitoring Guidelines of TG Noise).
- ✓ Establish guidelines on how to perform sensor calibration and mooring to avoid or reduce any possible mistakes for monitoring ambient noise (D 11.2.1). These common recommendations should allow traceability in case the sensor give unexpected results and help to obtain high quality and comparable data.
- ✓ Establish guidelines on the best signal processing algorithms for the preprocessing of the data and for obtaining the ambient noise indicators (D 11.2.1).

- ✓ Implement a Joint register of impulsive noise (D11.1.1) and hotspot map at Mediterranean Sea Region level by impulsive noise national data gathering and joint processing.
- ✓ Enhance collaboration among a wide network of stakeholders through the dissemination of the project results, knowledge share and networking.

To achieve its objectives, the project is divided in 5 work packages which relationships are shown in Figure 1.



Picture 1. Work Plan Structure

The project is developed by a consortium made up of 10 entities coordinated by CTN and it has a duration of 24 months starting on January 2017.

This document reports on the description of the International Noise Register for the Mediterranean Sea region (INR-MED) as developed during QUIETMED and the perspectives for its future management and maintenance.

2 Impulsive Noise Register in the Mediterranean Region.

The tool described in this document is the International Noise Register in the Mediterranean region, INR-MED. The INR-MED comes after the development by the International Council for the Exploration of the Sea (ICES) of the international noise register for the North-east Atlantic area (including the North Sea, the Celtic Sea, and the English Channel) and the Baltic Sea, i.e. the areas covered by the Regional Seas Conventions OSPAR and HELCOM, and has the same global objectives. It is indeed conceived to support ACCOBAMS in producing information that will feed regional assessments on underwater noise pollution, and its Contracting Parties to report on anthropogenic impulsive sounds either for the process relative to the Marine Strategy Framework Directive (MSFD) or the Ecosystem Approach (EcAp) led by Barcelona Convention.

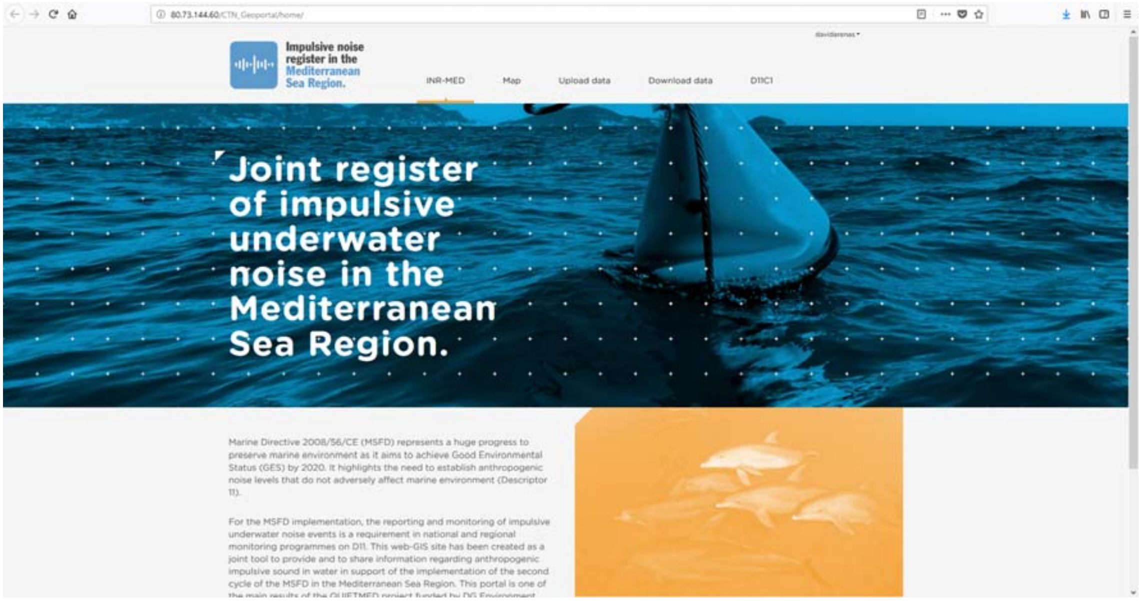
In providing a tool to respond to the relevant MSFD and EcAp processes, this document addresses important objectives of the Memorandum of Understanding between the Secretariats of ACCOBAMS and UNEP/MAP on topics related to underwater noise monitoring and assessment, and relevant provisions of ACCOBAMS Resolutions dealing with the management of the impact of anthropogenic noise on cetaceans (though limited to the Mediterranean Sea).

The INR-MED is based on the Impulsive Noise Register Demonstrator developed by ACCOBAMS for the Mediterranean and the Black Sea (Maglio et al., 2017) and the development took advantage of the work done by ICES for the OSPAR and HELCOM regions on the same topic (Holdsworth and Pinto, 2016).

Therefore, the tool was developed in line with Commission Decision 2017/848 and following guidance documents from TG-Noise (Dekeling et al., 2014). The INR-MED was conceived as a user-friendly tool which consists in a web GIS application that allows reporting noise events in a MS Excel spreadsheet template. Once the data are uploaded by the user, the reported noise events are displayed in a map interface and different types of indicators are calculated automatically and displayed. Furthermore, additional functions allow creating graphs, filtering relevant data, searching for metadata, and more. In addition, the application includes a download section where users can retrieve the data contained in the database.

The INR-MED calculates different indicators associated to Criterion 1 of Descriptor 11 of the MSFD (D11C1: Anthropogenic impulsive sound in water), i.e. quantities associated to the spatial and temporal distribution of underwater impulsive noise sources.

The INR-MED can be accessed and explored from the following URL: http://80.73.144.60/CTN_Geoportal/home/



Picture 2. Home page of INR-MED

2.1 Territorial scope

The INR-MED is intended to be applied in the Mediterranean Sea basin regions, subregions and subdivisions. According to MSFD, the designed marine region is the Mediterranean Sea and the marine subregions are: Western Mediterranean Sea, the Ionian Sea and Central Mediterranean Sea, the Adriatic Sea and the Aegean-Levantine Sea[1]. The INR-MED yet does not address the subdivision level since the process of defining subdivisions was ongoing during the development phase[2]. Therefore, D11C1 calculation will be found in two spatial scales: marine region and marine subregions.

The Mediterranean Sea geographic boundary was defined by MSFD GIS data files[3]. This geographic boundary is used to set the working area of the Mediterranean noise register. However, due to the extent of the Agreement area under ACCOBAMS competence, the Black Sea region is added to the map visualization in order to highlight the future development lines of the tool.

2.2 Description and functionalities

The functionalities of the impulsive noise register are divided in two groups:

- ✓ The functionalities belonging to the **noise register interface** group address the administration of the register, as well as the upload and download of data.

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0056&from=EN
[2] Two workshops were held on this matter: 1st and 2nd Workshop for the delineation of subdivisions relevant for MSFD assessments/reporting in the Mediterranean Sea, in Rome on June 21-22, 2017 and Athens on February 20th, 2018.
[3] See https://www.eea.europa.eu/data-and-maps/data/msfd-regions-and-subregions-1

- ✓ The **Web map GIS** group address the functionalities associated to the map application tool.

2.2.1 Noise Register Interface

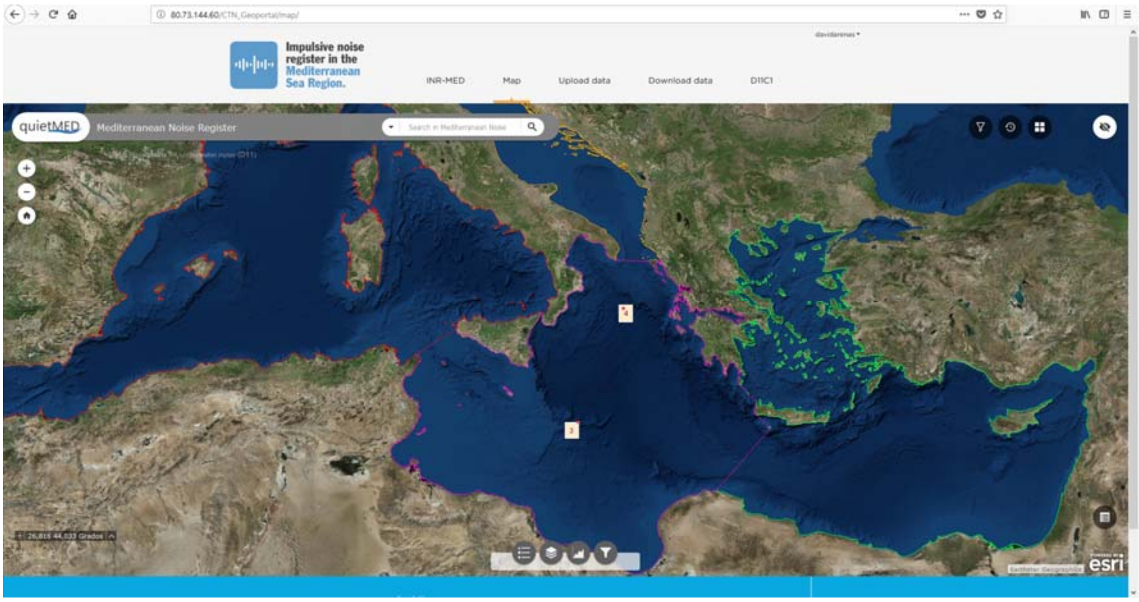
2.2.1.1 INR-MED Homepage

This section is an introduction of the joint register of impulsive underwater noise in the Mediterranean Sea Region. The home page explains the aim of the Marine Directive 2008/56/CE (MSFD).

2.2.1.2 Map

The collected data in the noise register is displayed in a map as points, lines, or polygons. Once collected data is processed, it is instantly displayed by the web application (this action occurs at the submission of data to the register database). The application also calculates the corresponding pulse-block days (see Annex 6.1 – Criterion calculation) and the result is displayed in the map.

The data visualization in the web map is powered by the web service visualization of ArcGIS for Server that provides style symbology, layer order, legend information among others. In the map page, several common web GIS tools can be found such as filters, pop-ups, table of attributes and metadata, legends, and more. All these tools will be deeply described in Section 2.2.2.



Picture 3. Map page (http://80.73.144.60/CTN_Geoportal/map/)

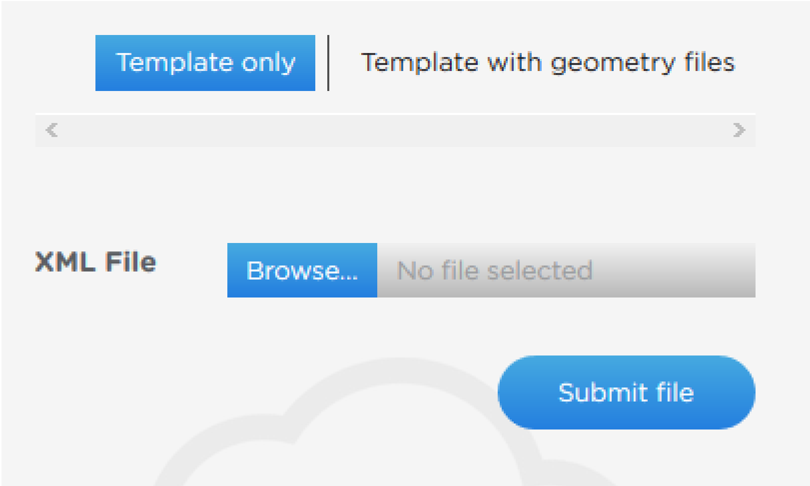
2.2.1.3 Upload

To ensure compatibility with other the OSPAR and HELCOM registers, the same reporting system of those areas is adopted, based on the use of an Excel template. The reporting procedure is as follows:

1. The user downloads the "Underwater Noise Register Template for the Mediterranean Region" in Excel format (available at http://80.73.144.60/CTN_Geoportal/upload/)
2. Fulfills the required fields of the downloaded template as described in Annex 6.5- *Excel template for data reporting from Member-States*
3. Transforms the Excel template in XML format by clicking on the button "Export data to XML for QUIETMED". The button is located in the Excel template (sheet *_Instructions_Export*)
4. Uploads the generated XML using one of the options described below (Picture 4 and 5) and clicking on "Submit file".
5. If the upload process is successful, the application will show the message "Data uploaded successfully".
6. Data are printed in the map.

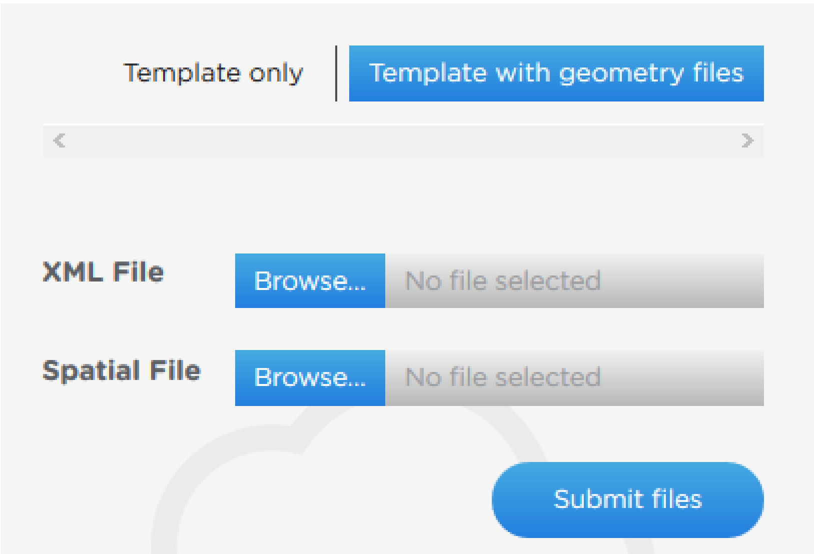
There are two possibilities to report spatial data:

- Report underwater noise data with only XML template: For noise events (which are represented as points in the map) such as pile driving and explosions, indicates its latitudes and longitudes in the Excel template. This is particularly handy for specific users, i.e. country's institution(s) with the responsibility to report about this kind of phenomena. In the case of events represented by polygons (e.g. moving noise sources like seismic sources, or sonars), the adoption of the regular spatial grid of the General Fisheries Commission for the Mediterranean (GFCM) is conserved from the ACCOBAMS Register Demonstrator (see **Annex 6.4** of this document); this option implies that the user indicates the identifier (ID) of the GFCM statistical rectangles (referred to as just grid cells in this document) where noise sources appear. Also, as for the OSPAR and HELCOM regions, the register is conceived to allow countries to report noise events using their own national spatial grids. We must underline that the national grid system would be only to report, i.e. to indicate in what nationally-designated grid cell noise events occurred. To compute the indicators, the register will use the regional GFCM grid. Currently, the only existent national grid system included in the register is from France. To report noise event with through any of these reporting options the user shall select the desired geometry type in the INR-MED template.



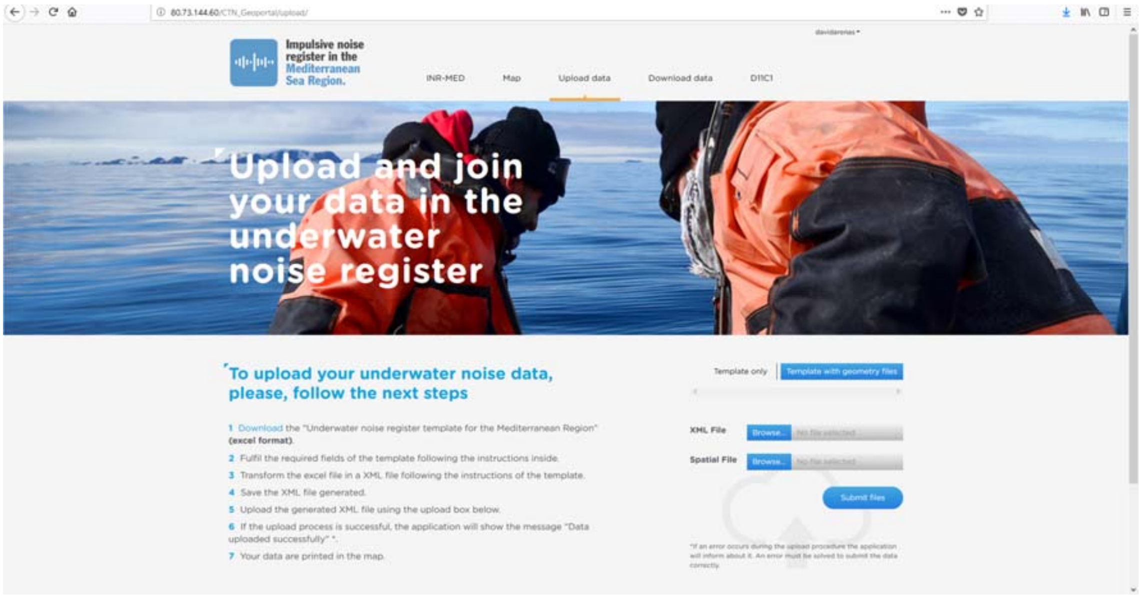
Picture 4. Template form for XML data upload (http://80.73.144.60/CTN_Geoportal/upload/)

- Report underwater noise data with XML and spatial files: the upload functionality supports noise reporting with spatial files. Available formats of spatial files are KML and SHP, and the supported geometry types for the noise register are points, lines and polygons. This option requires to complete and upload the Excel template (transformed in XML file) like in the first case because the information describing the reported underwater noise event (start and end dates, intensity, etc.) is collected in the XML file, while the spatial objects only contain information about geometries of the noise event. The main advantage of this option is that the user can upload noise events using his own geometries. Noise event data submitted in such a way will be standardized spatially by the web application through the intersection with the GFCM grid.



Picture 5. Template form for spatial file upload (http://80.73.144.60/CTN_Geoportal/upload/)

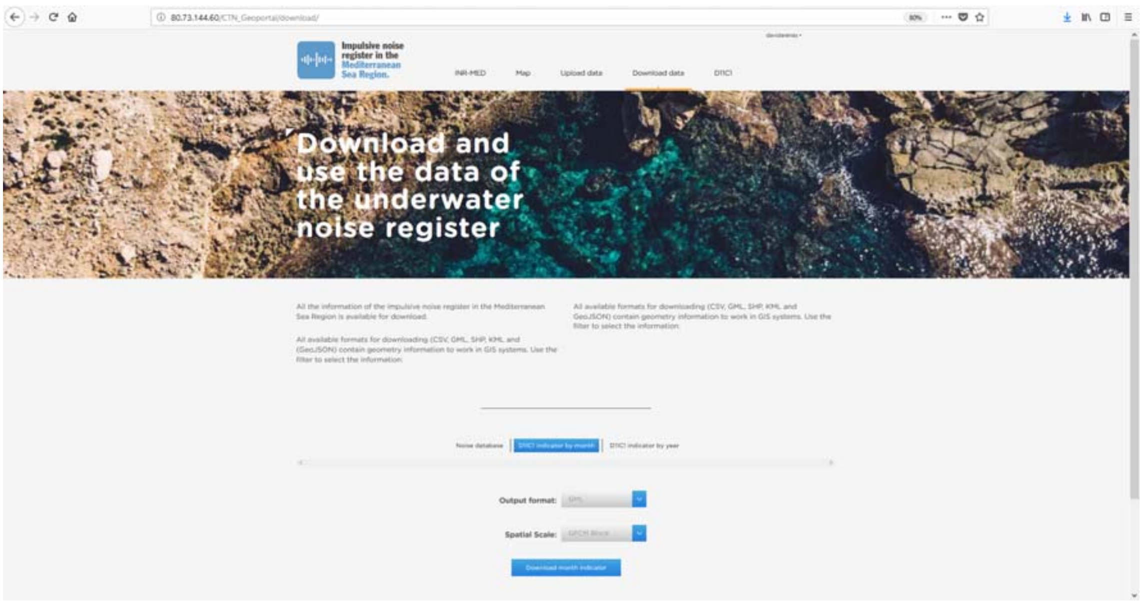
During the upload process, the XML file is automatically checked for errors. An alert message will pop up to the user if a problem happens during the upload procedure. The alert contains detailed information on the error occurred.



Picture 6. Upload noise events section (http://80.73.144.60/CTN_Geoportal/upload/)

2.2.1.4 Download

Information contained in noise register is available for download. The user can download noise events or the different kinds of noise indicators. Supported file extension are SHP, KML, GeoJSON, GML and CSV. User has the option to download a specific amount of data from the database applying filters directly to the data. With this possibility the user can select only the desired data for download avoiding waiting times on large data requests.



Picture 7. Download noise data section (http://80.73.144.60/CTN_Geoportal/download/)

2.2.1.5 *Admin interface*

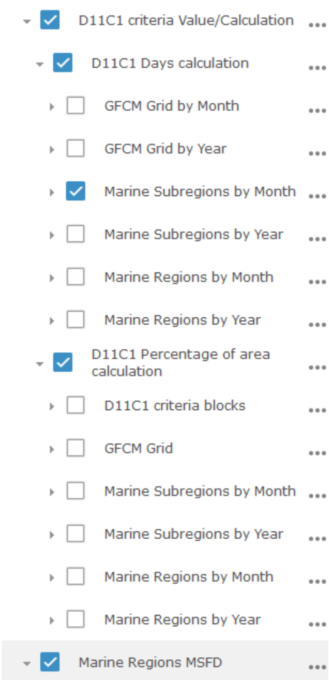
An admin interface was implemented to the noise register to allow its management by administrators. The admin interface capabilities are user management and database functions principally. Administrators can search, view, filter, add, update and remove data in the noise register by accessing to the database tables section.

The remove function on noise data reported by member states recalculates the D11C1 results in order to show the correct value of days with impulsive sources per month/year. When a noise data is deleted the application checks if the deleted noise is involved in any D11C1 calculation. If the deleted noise data is not involved in any D11C1 calculation the application deletes the noise event without any other action. Otherwise, if the deleted noise data participates in D11C1 calculation the application deletes the noise data and recalculates D11C1 values for the GFCM grid, marine subregions and marine regions involved with the deleted noise data.

2.2.2 Web map GIS

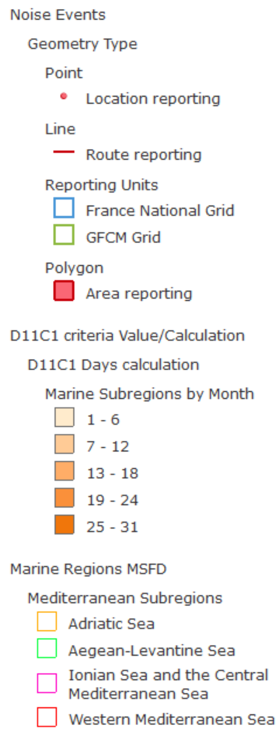
Several GIS functions are implemented in the map page of the INR-MED, allowing the user to navigate, search and viewing noise event data, viewing D11C1-related indicators and exploring metadata:

- Layer Switcher: Tool to select layers to be displayed in the map. The user can interact with this tool selecting the desired available layers in INR-MED to be visible. However, notice that INR-MED includes approximately twenty selectable layers. Selecting a big amount of this layers may produce a low performance in time loads and poor visualization experience for the user. For example, D11C1 layers will contain a huge amount of information over the years, a property of GIS is that overlapping layers are not shown under the top layer, so in some cases there are some layers that are loaded in the map but are not visible. To solve this issue a tool for filtering (D11C1 Visualizer) was developed to achieve a better visualization and time loads using preestablished selectable parameters. With this procedure the user can see information contained in the noise register easily and faster, avoiding mistakes in layer selection.



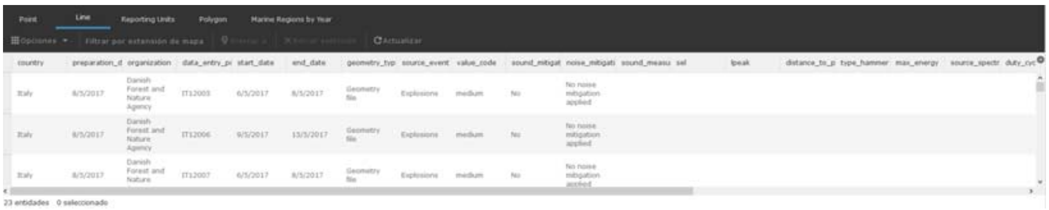
Picture 8. Layer switcher widget

- Legend: the legend of the INR-MED is dynamic because is designed to adapt to changes set in the map visualization. This tool shows the symbology and description of each represented element of the map.



Picture 9. Legend of INR-MED

- Table of attributes: Geographic data usually has associated information and metadata. INR-MED has implemented a table of attributes tool to see the associated information to the geographic data, to select database records (e.g. noise events) or apply filters to data. The table functionality allows the user to select the data from the table and see the selected records in the map. Filtering data is the most powerful functionality of table of attributes. With this feature is possible to show only desired data in the map and it can be applied over all the layers belonging the noise register.


Point | Line | Reporting Units | Polygon | Marine Regions by Year

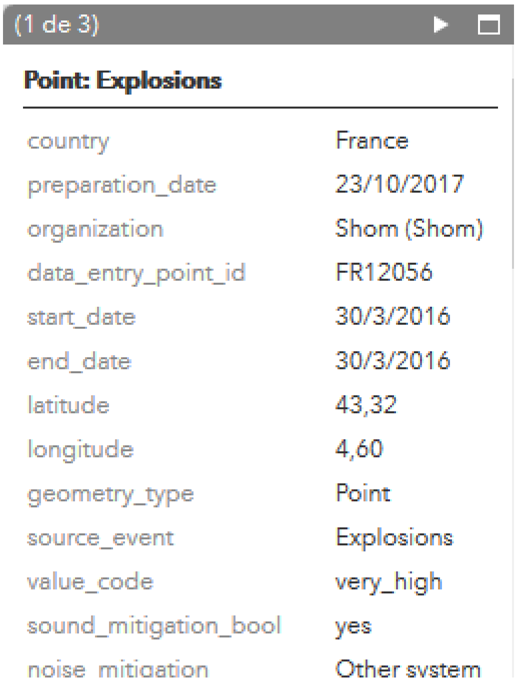
Opciones | Filtrar por extensión de mapa | Actualizar

country	preparation_d	organization	data_entry_pi	start_date	end_date	geometry_typ	source_event	value_code	sound_mitigat	noise_mitigati	sound_measu	sel	lpeak	distance_to_p	type_hammer	max_energy	source_spectr	duty_cyc
Italy	8/5/2017	Danish Forest and Nature Agency	IT12005	6/5/2017	8/5/2017	Geometry file	Explosions	medium	No	No noise mitigation applied								
Italy	8/5/2017	Danish Forest and Nature Agency	IT12006	9/5/2017	13/5/2017	Geometry file	Explosions	medium	No	No noise mitigation applied								
Italy	8/5/2017	Danish Forest and Nature	IT12007	6/5/2017	8/5/2017	Geometry file	Explosions	medium	No	No noise mitigation applied								

23 entidades 0 seleccionado

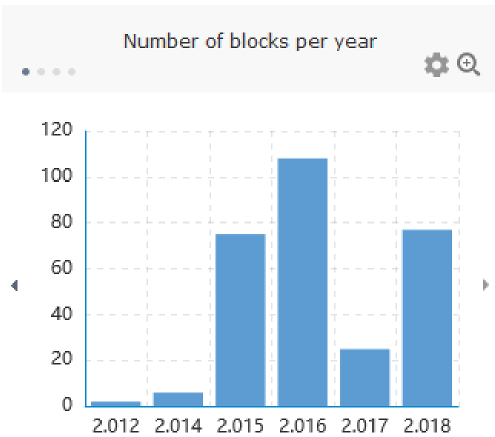
Picture 10. Table of attributes widget

- Pop-ups: Pop-ups are based on a floater window that is shown when the user clicks on noise events in the map. The principal advantage of pop-ups is that the user can see the selected record in the map directly. The information appearing in the pop up is retrieved from the database. However, pop-ups window only provides information about the selected elements one by one.

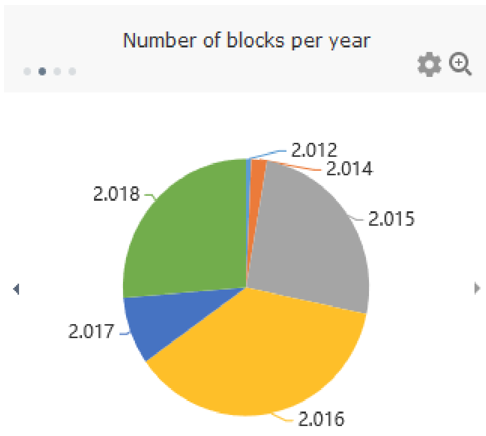


Picture 11. Pop-up related to a point feature

- Graphics and charts: This tool plots information contained in INR-MED as graphics in different formats (bar, columns, pie and line charts). Graphic tool enables the analysis of information in a visual way. For example, charts can show in what year there are more reported noise events as can be seen in the pictures below.

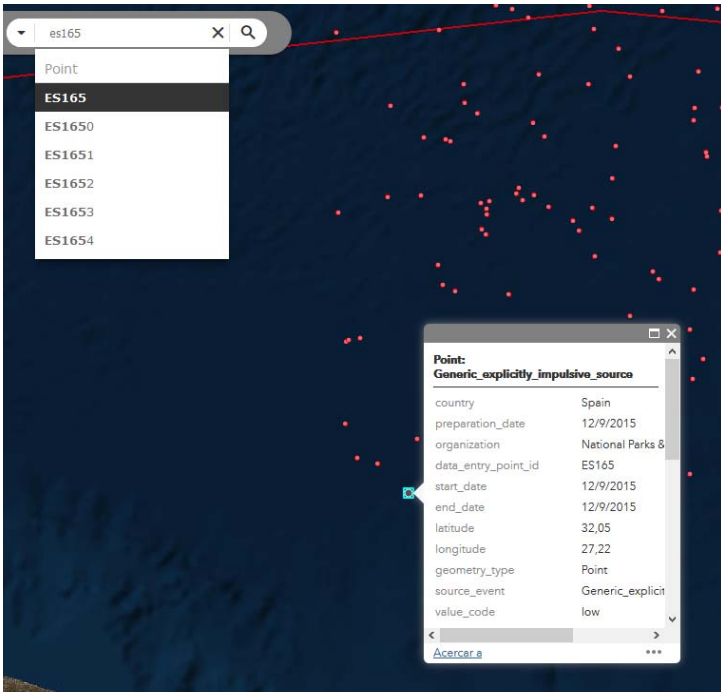


Picture 12. Column graph generated by Mediterranean noise register



Picture 13. Pie chart generated by Mediterranean noise register

- Geocoder: This function consists in a search bar configured to search and reach data in the map by typing the information related to searched data (codes, dates, etc.). This means that the user can search a noise data by the identifier value and zoom it automatically when the search button is pressed. This functionality is combined with the pop-up tool (Picture 14).



Picture 14. Search widget looking for ES165 noise event

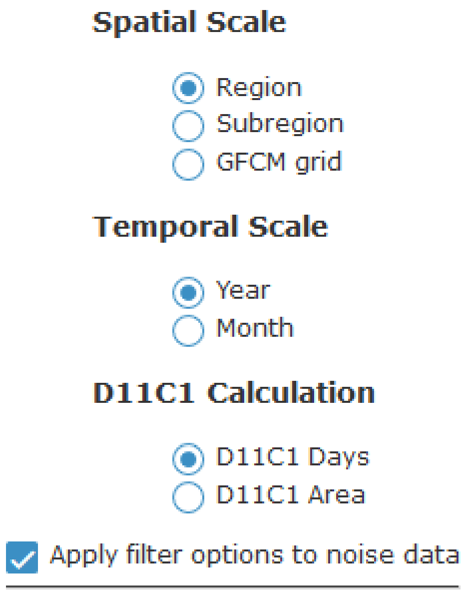
- Get coordinates: this tool aims to take a coordinate from the map view with user click interaction. The available geographic coordinate system in INR-MED are the next:
  - WGS 1984.
  - ETRS 1989.

  The tool works by pressing the get coordinates button (left icon of element shown in Picture 15) and pressing in a map zone to obtain the coordinates.

  Coordinates are shown in decimal degrees.

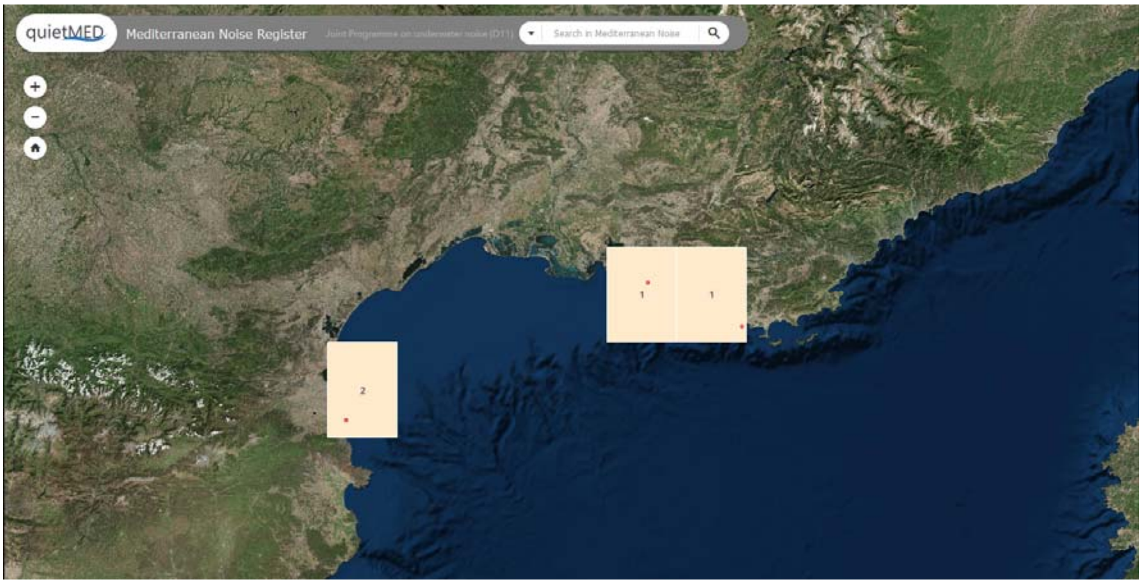
Picture 15. Get coordinates widget

- D11C1 filter: This tool was created to give a comfortable user experience in viewing data from many layers. The D11C1 filter allows the user to select a spatial scale (Region, Subregion or GFCM grid), a temporal scale (year or month) and a calculation type (days or area percentage) to show D11C1 values. Once those parameters are selected, the user indicates what year and what month the data will be shown in the map. Furthermore, an optional checkbox (apply filter options to noise data) is provided to apply the same filter to noise event data.



Picture 16. D11C1 filter widget

The *Apply filter options to noise data* checkbox synchronizes the noise event data with D11C1 criterion values as it can be seen in the figure hereafter.



Picture 17. Screenshot of INR-MED. D11C1, pulse-block days in June 2016 represented in GFCM blocks, with corresponding noise events within the blocks, represented as red points (courtesy of SHOM)

2.3 Technical considerations

2.3.1 Available spatial object types

The INR-MED supports the most common spatial object types used in GIS applications. The reported noise events can be uploaded and represented indeed as points, lines and polygons. As such, the reporting precision is improved, compared to the OSPAR-HELCOM register, for those noise sources that appear less adequately represented as point features or as fixed blocks. The precision improvement applied to the noise events is already translated to a better estimation of the D11C1 criterion to some extent. However, further developments of the register will be necessary to better exploit this improved precision, for example by adding finer resolution grids for D11C1 representation, or further calculations such as shooting density of seismic vessels, amongst others.

2.3.2 A regular spatial grid for the INR-MED as reporting units

For calculating D11C1, the ICES uses the spatial grid for fisheries management in the North-East Atlantic. The indicator value is calculated in each grid cell (called statistical rectangle) and the result is a hotspot map. In the other hand, INR-MED uses fisheries management grid developed by the General Fisheries Commission for the Mediterranean (a regular grid with cell size of 30’ in latitude and longitude). The reasons in favor of adopting the GFCM grid instead of just using the ICES statistical rectangles are the following:

- The GFCM grids already exists, has a coding system (see annex 6.4 to this document) to identify unique grid cells, and it covers the whole Mediterranean and Black Sea areas;
- The ICES grid does not cover the whole Mediterranean Basin, just the northern part; Therefore, using the GFCM grid prevents us from developing a new coding for additional ICES grid cells in the Mediterranean. Additionally, the coverage of such portion of the Mediterranean is incidental as the ICES competence area is the North Atlantic (including the North Sea, the Baltic Sea and the English Channel).
- The GFCM grid addresses the potential overlap between ICES and GFCM grids in the Gibraltar Strait[4];
- The underlying concept for the GFCM grid is the same than the ICES grid, i.e. a grid for regional fisheries management.

Therefore, the adoption of this grid appears relevant for the INR-MED developed in the framework of QUIETMED. However, it should be considered that for the EcAp-Ecological Objective 11, a different grid (20 x 20 km) was proposed, based on cetacean management

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[4] See https://www.google.fr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwidkfXy7-PYAhWELsAKHbtHBuoQFggoMAA&url=https%3A%2F%2Fcircabc.europa.eu%2Fwebdav%2FCircaBC%2FMARE%2FMDR%2FLibrary%2FDocumentation%2FStatRecGrids_130703ma.doc&usg=AOvVaw0sVpfot-V3gmQCRf6Bvb5I

purposes (UNEP/MAP, 2016a). The Register Demonstrator for the Mediterranean area developed by ACCOBAMS (Maglio et al., 2016a) included both spatial grids. However, it appears today that the 20x20 km grid might not be suitable for the reporting of noise events, mainly because of the lack of a coding system with unique IDs corresponding to single grid cells. Instead, this grid (and potentially others) can well be used for analysis purposes, and this would be also consistent with the INSPIRE Directive.

In conclusion, the reporting units (usually referred to as “blocks”) for the INR-MED described in this document are the statistical rectangles originally developed by the GFCM and available publicly. Noise events can be reported for each block of this grid by indicating the identifier value (ID) of the desired block. This system avoids uploading additional spatial data (shapefiles or other formats). Further, the grid shall be used for calculating pulse-block days and for representing hotspot maps.

2.3.3 Further reporting units

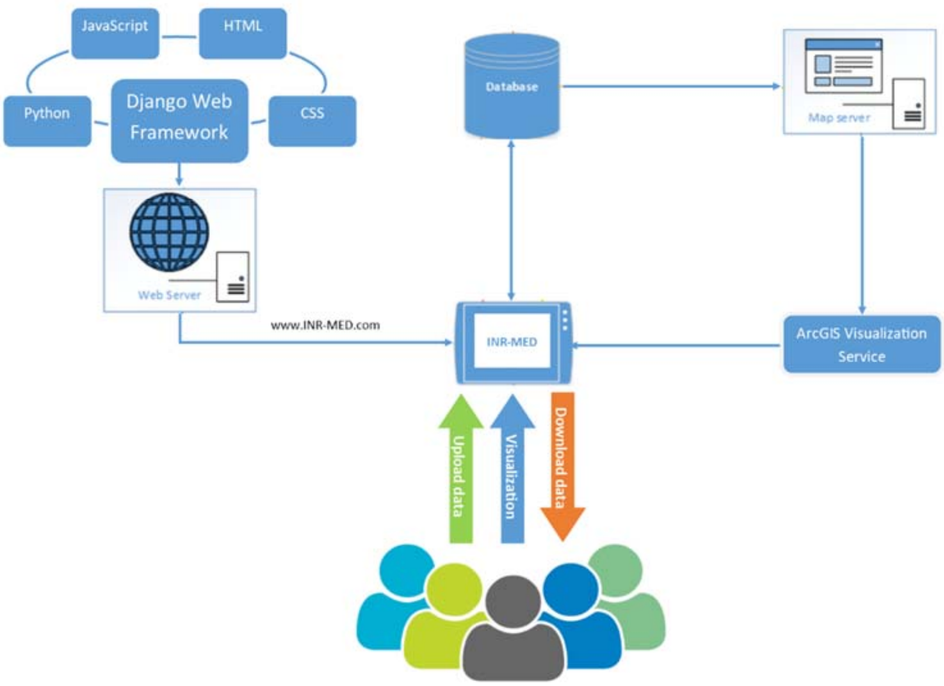
The INR-MED reporting procedure is also conceived to allow countries to report data with their own spatial reporting format. The only national units available in the INR-MED at the moment of writing this report are those of France.

2.4 Technologies and architecture

The technology schema of INR-MED can be divided into three parts: web development, GIS and user’s structure. It should be noted that PostgreSQL database are shared by web server and map server structures because they use the database connection for different purposes.

2.4.1 INR-MED schema

The following schema aims to show how the different technologies applied in QUIETMED are related to each other.



Picture 18 – QUIETMED technologies scheme

The schema is described in the points below:

- The web development structure (web server, Django, Python, JavaScript, HTML and CSS) aims to publish the INR-MED via internet in order to make it available for everyone. This part interacts with the database when users upload or download data.
- It is important to mention that the connection between INR-MED and the database is bidirectional because the information uploaded by the user is stored in the database and in the same way, that information can be downloaded using INR-MED functionalities developed for that matter.
- Regarding the GIS part, the database information is requested by the map server using SQL sentences previously designed. The map server reads the geometry type column of the retrieved tables by the SQL sentences and plots the result in a map. After, the generated map is published as visualization map service to be used in web mapping applications. When the map is published, the users can connect to INR-MED and visualize the underwater noise uploaded data and indicator data in the map section.

2.4.2 Description

Technologies used to develop noise register are described hereafter:

- **Web development structure**: This part of the INR-MED structure has a couple of web technologies related to each other. The technologies used are the standard for web development (using Python environment) such as Django web framework, Python programming language, JavaScript, HTML and CSS. To publish the web page a web server software is required. In this case, the web server used to publish the INR-MED web page is Apache2.

- Django web framework: Django pursues the fast development of web pages. Django provides utilities to make easier the development work as for example connection with the database or an administrator panel. HTML, CSS and JavaScript forms a perfect team in combination with Django web framework because Django uses a HTML template system that allows to reuse templates and insert Python code using special tags. For GIS development, the GeoDjango extension applied. This extension provides functions to work with geographical data. Django is written in Python, so that ensures full compatibility with other technologies used in the project.
- Python: Python works in the server side making the most complex calculations in the noise register or the database management. Due to the large number of tools to solve problems related with geographic information, Python is one of the most used languages in the GIS community and was chosen for the development of the INR-MED.
- JavaScript: in QUIETMED project JavaScript was used mainly for simple tasks. JavaScript is a programming language that is executed in the client side and is used principally to user-web page interaction. The map application of INR-MED was created using an API write in JavaScript.
    - API maps: an API is an Application Programming Interface that is used to build application software. To build the map section (http://80.73.144.60/CTN_Geoportal/map/) of the noise register the ArcGIS API for JavaScript was used.
- HTML5: HTML language is used to create the structure of web pages. HTML is a tag system where each tag has a specified function in the web page. To complement this language Cascading Style Sheets (CSS) must be used to give graphical design.
- CSS: Cascading Style Sheets are used to format the layout of web pages. CSS usually is used to make web pages responsive in size and form for all screen's modes.
- Web server: Apache2 was used to deploy the application of the Mediterranean noise register. Apache2 is one of the most used web servers to create web pages and has full compatibility with Django, Python and GIS projects.

- **GIS structure** (serving geographic data on the web): ArcGIS for server is the core program of this part.
    - ArcGIS for Server is a powerful software to publish geographic data on the internet. ArcGIS for Server is based on a graphic interface which is used to

publish spatial data in an easy way. Furthermore, ArcGIS for Server uses the powerful software ArcMap which prepares the data to be published.

- Web service protocols: to enable visualization of geographic files via the Internet, web services are used. ArcGIS provides protocols to share geoinformation online. The visualization service is used to display the data in a map. This service contains the information of the coordinates, symbology styles, layer order, values, etc. In visualization services the data is processed in the server side and is returned as an image to the client, this means that time loads are faster than other service protocols as feature services, because the major part of the calculations are made in the server side.
- Spatial database: PostgreSQL database, complemented with PostGIS extension, is used to store the data of the noise register. This choice allows handling spatial data in a relational database, as the conception of the register requires.

- **User's structure**: The users have the possibility to upload their data, download data contained in the database and visualize the geographical data of underwater noise in the map page of the noise register.
  - Upload data: INR-MED provides an upload section where users can upload underwater noise data in XML files. This procedure is explained in Section 2.2.1.3.
  - Download data: Users can download the data from the database easily using form selection to download the desired data. In Section 2.2.1.4 is explained how works the download functionality.
  - Visualization in a map application: The visualization of data is made using a map application created with AppBuilder. AppBuilder is an intuitive what-you-see-is-what-you-get (WYSIWYG) application that allows you to build 2D map applications. More information about the map page can be found in section 2.2.1.2.

3 Hotspot maps and D11C1 calculation

Hotspots maps in the INR-MED report the number of pulse-block days per unit areas, per month or per year. In this chapter we describe the choices that were made on how to perform computation of such quantities and discuss the consistency with Commission Decision 2017/848 and with guidance from TG-Noise on D11 implementation.

3.1 Recalling guidelines from Commission Decision 2017/848 on methods for monitoring and assessment

The Decision states that the extent to which GES has been reached will be determined based on:

"The duration per calendar year of impulsive sound sources, their distribution within the year and spatially within the assessment area, and whether the threshold values set have been achieved".

Further, the Decision gives the units of measurement for the monitoring and assessment of the impulsive noise criterion:

"D11C1: Number of days per quarter (or per month if appropriate) with impulsive sound sources; proportion (percentage) of unit areas or extent in square kilometres (km^2) of assessment area with impulsive sound sources per year".

However, there are a number of ambiguities related to this last definition and therefore on how to perform the calculations:

1. How to deal with noise events having overlapping periods for the same unit area(s)?
2. How to calculate areas and proportion of areas (percentages)?
3. How the *pulse-block days* metric, as defined by TG-Noise (Dekeling et al., 2014), fits to the new Commission Decision to derive D11C1 indicators?

The first two ambiguities are discussed in 3.2 and 3.3 below and the approaches selected here are explained. Solving the third ambiguity requires discussing the language used in the Comm. Dec. 2017/848, recalling the work done by TG-Noise until 2014, and proposing an interpretation that matches the objectives of the INR-MED and meets the requirements of the MSFD. Therefore, it deserved a more thorough analysis that QUIETMED partners performed during the project duration, and which is presented in Annex 6.1.

3.2 D11C1 Days

The calculation method D11C1 for QUIETMED is based in the metric called "pulse-block days" (PBD) proposed by TG-Noise, which considers the number of days one or more impulsive noise events (pulses) occur in a block. Here the concept of "block" applies to grid cells of the spatial grid selected for the INR-MED, as well as to each subregion and to the whole region. For several impulsive noise events, in case they occur in the same day, only one day will be counted in the computation process. When the number of days and the position of an impulsive noise event are known, the application calculates D11C1 values considering two cases:

- If there are no previous calculations for the block where the new impulsive noise event is located. In this case, the result for D11C1 calculation will be equal to the number of days of that impulsive noise event.
- If there is a previous D11C1 calculation for the block where the new impulsive noise event is located. In this case, an algorithm matches the start and end dates of the new noise event against previous noise events already recorded in the database for that grid cell, and only non-coincident days will be taken into consideration for D11C1 calculation.

Considering that these conditions apply to all kinds of blocks (grid cell, subregion and region), it means that the maximum value for D11C1 will be 365 over a year, whatever the block is (grid cell, subregion or region). If we are assessing over a month, the maximum value for each grid cell, marine subregion and region will be 28, 30 or 31 pulse-block days depending on the month.

Some differences exist compared to the current version of the international noise register for the OSPAR and HELCOM regions (as in October 2018):

A) The "pulse-block day" calculation in such regions gives the number of days with impulsive sound sources over a year while the INR-MED provides also the monthly calculation as outlined in the Commission Decision 2017/848

B) More refined GIS functions are built in the INR-MED to avoid area overestimation in the calculation process. Detailed description of such functions (spatial lookups) are provided in section 6.2.

C) In the OSPAR and HELCOM register application, bar charts represent, for each assessment area, PBDs by noise event intensity level (very low, low, medium, high and very high). This option was not implemented in the INR-MED.

D) An indicator named "Total Pulse Block Day" is provided for the OSPAR and HELCOM regions. The "Total Pulse Block Days" is the sum of pulse-block days from all grid cells for a determinate marine region or subregion and can therefore exceed 365 days (366 in leap years). For the INR-MED, the calculation of pulse-block days is based on the count of non-coincident days for all kinds of spatial units (GFCM blocks, marine subregions and for the whole region), and therefore the maximum pulse-block day value is 365 (or 366) for a year, and 28, 30 or 31 for a month (depending on the month). This choice provides an easy manner for comparing and assessing spatial units among them.

E) A regular fishnet is used in the two registers to cover the respective areas, but this has different dimensions. The noise register developed by the ICES is delimited by a fishnet named ICES sub-rectangles which are 10' in latitude and 20' in longitude. The ICES sub-rectangles are derived from the ICES statistical units having a size of 30' in latitude and 1º in longitude. The sub-rectangles are made by dividing each ICES statistical unit into nine. In the case of INR-MED the grid used to calculate D11C1 indicator is the grid implemented by the General Fisheries Commission for the Mediterranean (GFCM)[5].

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[5] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiS4r71wsbdAh

GFCM grid has a size of 30'x30' and covers all Mediterranean and Black Sea area. The reason for choosing another grid system for INR-MED is because ICES sub-rectangles doesn't cover the Mediterranean area, while GFCM grid covers the entire Mediterranean Sea and Black Sea. Besides, GFCM grid is developed with a stable coded system to identify each grid cell of the fishnet. This fact gives quality and an easy implementation in the Mediterranean noise register.

F) The noise register developed by ICES uses an additional grid system, named c-squares. that is a standard grid that covers the entire world. Benefits of using this grid are full coverage of this grid in all regions, text-based, human- and machine- readable format, some pre-established block sizes (0.5ºx0.5º, 1ºx1º, 5ºx5º…) and codes identifying each cell. For the Mediterranean noise register, c-squares will be assessed in the future in order to implement them if appropriate.

3.3 D11C1 Area

To avoid typical problems related to calculations of areas in GIS (particularly deformations due to the projection of coordinates), the solution adopted for the INR-MED is to calculate spatial quantities in terms of area percentage, and not in terms of extent in km². The percentage is calculated as the ratio of the number of grid cells with pulse-block days (PBDs) to the total number of grid cells of a marine region or subregion. Therefore, when a block of the GFCM grid has an impulsive noise event contained in it (no matter how many PBDs), that block participates in the calculation of this percentage for the period of reference (month, or year). In short, the area percentage is the result of the sum of all blocks that contains impulsive noise events divided by the total blocks for the Mediterranean region or the Mediterranean concerned subregion (See Annex 6.1 for further explanation).

To do this procedure, *intersects* spatial function (a common GIS operation) is used to determine the number of GFCM grid cells that crosses a determined marine region or subregion. By applying this operation, grid cells that are intersecting two marine subregions will be considered twice but given the extension of the marine subregions compared to the extension of grid cells, this is considered a negligible error. Further development of the register may be aimed at reducing this error.

VjyoUKHcJ3BYgQFjAAegQIABAC&url=https%3A%2F%2Fcircabc.europa.eu%2Fwebdav%2FCircaBC%2FMARE%2FMDR%2FLibrary%2FDocumentation%2FStatRecGrids_130703ma.doc&usg=AOvVaw0sVpfot-V3gmQCRf6Bvb5I

4 Compatibility with regional and national registers.

The regional impulsive noise register presented in this document is primarily designed to support consistent regional assessment in the ACCOBAMS area and the reporting by ACCOBAMS Contracting Parties to MSFD-D11C1 (EcAp-EO11 concerning non-EU countries).

High compatibility with the ICES register was sought since two countries, France and Spain, will report for both the Atlantic and the Mediterranean area. It appeared obvious indeed to find a way to avoid, as far as possible, any extra effort for submitting data to the Mediterranean register than already required by the ICES system.

The development phase also considered the monitoring programs for D11C1 in Mediterranean EU Member States being at an advanced stage of implementation[6], in order to:

- allow such Member States to easily submit their data to the regional register through a system compatible with their national tools;
- provide a common framework for those countries at earlier stages of implementation of monitoring programs for D11C1, with a view of avoiding large divergences in the future at the regional scale.

A benchmark analysis was finally done to highlight convergence and divergence in choices done for the different existing registers; Such benchmark is proposed in Table 1 below. The demonstrator tool developed by ACCOBAMS before the beginning of QUIETMED is also mentioned in the table.

Table 1 Comparison among noise registers. * The Italian register is not yet validated. ** The ACCOBAMS demonstrator of a noise register will no longer be online once the tool developed within QUIETMED will be turned operational.

Feature	Italian register*	French register	ACCOBAMS demonstrator**	ICES register	QUIETMED register
Form for data reporting	Spreadsheet	Spreadsheet	Spreadsheet	Spreadsheet	Spreadsheet
Geometries used	Points, polygons, grid cells from pre-established spatial grid	Points, polygons, lines	Points, polygons	Points, grid cells from pre-established spatial grid	Points, polygons, lines, grid cells from pre-established spatial grid
Use of pulse-block days as metric	Yes	Yes	Yes	Yes	Yes
Use of a spatial grid	Yes	Yes	Yes	Yes	Yes
Grid dimension (lat x long)	30'x30'	15'x15'	30'x30'	10'x20'	30'x30'
Public access to some information (no log-in)	Yes	No	Yes	Yes	Yes
Information on mitigation	No	No	No	Yes	Yes

[6] Two countries, France and Italy, were considered at an advanced stage of development concerning the implementation of D11C1 as at least main tasks were carried out and information is publicly available on achievements (monitoring programs, tools, databases, data collection, etc.).

measures is analysed and presented					
Future planned events (permit requests)	yes	No	No	No	No
Download of indicators	Not publicly available (login necessary)	No	Yes	Yes	Yes
Download of row data	Not publicly available (login necessary)	No	Yes	Yes	Yes

Differences shown in the table concern some important questions on the objectives of D11C1 monitoring at both the national and regional scale. Especially, the potential of the register as a planning tool (as highlighted in TG-Noise guidance documents) is being expressed only by one tool analysed here. Further, the download of data and information is limited or not possible for national countries while it appears feasible for regional tools. Likewise, information on mitigation measures is presently not included in national register analysed here, while it is for regional tools. Therefore, including such information at the national level appear crucial to monitor the implementation of mitigation measures at the regional scale, as national registers are the only source of data for regional tools.

Despite the highlighted divergences, all the tools compared here (including the INR-MED) use common methodologies for data reporting (a spreadsheet), calculating indicators (based on the pulse-block days metric), and representing results (through a spatial grid in a GIS system).

5 Perspectives for the management and the future development of the impulsive noise register

5.1 ACCOBAMS geographical scope: Mediterranean and Black Sea

The ACCOBAMS Agreement area covers the Mediterranean Sea, the Black Sea and a small portion of Atlantic Ocean close to the Gibraltar Strait. Further, an extension area of the Agreement covers also Portuguese waters. However, the envisaged competence area of the international noise register managed by ACCOBAMS extends to the Mediterranean Sea and the Black Sea. This is due to the fact that the Atlantic portions covered by the ACCOBAMS Agreement are already addressed by the noise register of the OSPAR region.

In order to ensure sustainability of the regional impulsive noise register after the end of the QUIETMED project, the possible management framework has to be considered. Different possibilities exist and are addressed in the next sections.

5.2 Long-term management of the register

The legal background in place giving ACCOBAMS the competence to manage underwater noise in the Mediterranean Sea, can be summarised as follows:

- Six Resolutions on noise management and mitigation adopted by the ACCOBAMS Parties (24 countries, including 8 EU-Member States in the Mediterranean), and the Resolution related to the Working Programme that provides for the establishment of a common database on impulsive noise sources during the 2017-2019 period.
- A Memorandum of Understanding in place since 2016 between the Secretariats of ACCOBAMS and the UNEP/MAP-Barcelona Convention on issues concerning underwater noise and cetaceans. This MoU reinforce the cooperation between the two organisations, particularly concerning the implementation of the EcAp process.

In light of this, the following options could be considered:

- Option 1: a direct management from the ACCOBAMS Secretariat. In this case, the register will be hosted directly in a server managed by the ACCOBAMS Secretariat and it will be available from the ACCOBAMS website or from the NETCCOBAMS portal (http://www.netccobams.com/)
- Option 2: a direct management by UNEP/MAP through the InfoMAP system (data portal of the Barcelona Convention – under development)
- Option 3: a shared management according to different levels of responsibilities. In this case a connection is in place between the register, which would be managed by ACCOBAMS (for example through the NETCCOBAMS portal) and the UNEP/MAP's InfoMAP system: data and information are therefore available for the periodical regional assessments (QSR), which UNEP/MAP is responsible for in the Mediterranean Sea.

Further, as previously mentioned, the ACCOBAMS Area covers both the Barcelona Convention and the Bucharest Convention areas, so that a unique register might become the common tool for the two Regional Sea Conventions. This might be seen as a fourth option, where the Black Sea Commission is also part of the shared management of the noise register.

The 3rd and 4th options appear as the most similar to the framework in place in the OSPAR and HELCOM regions, where ICES manages the register for such two RSCs, and data are available for the periodical regional assessments.

From the institutional point of view, the discussion and the final proposal for a management framework is a matter to be addressed by the Meeting of the Parties to ACCOBAMS, considering recommendations from the ACCOBAMS Scientific Committee. Furthermore, as far as the cooperation with the Barcelona Convention, and the Bucharest Convention, is fruitful and successful, the decision about the adoption of the work carried out in QUIETMED for the purposes of EcAp (and related initiatives in the Black Sea) involves further bodies, such as: the MEDPOL, the Coordination Unit of EcAp, the Conference of the Parties to the Bracelona Convention, as well as all the appropriate bodies within the Bucharest Convention.

Finally, a first assessment of the financial requirements for the maintenance of the system has already been done in the framework of QUIETMED.

5.3 Envisaged national responsible institutions for data reporting

During the project, a survey among partners was carried out in order to identify the potential responsible institutions for the upload of national data and other management related to the international register from the national perspective. The following table summarizes the information collected during the project.

Country	Institutions working on D11C1	Potential responsible institution for data submission	Possible periodicity for submission	Comments
Croatia	IOF	IOF		
Cyprus	No data available	No data available	No data available	
France	Shom (national coordinator), Data providers (Navy, public bodies Institutes, Competent authorities for licensed activities)	SHOM	yearly	
Greece	HCMR	HCMR		
Italy	CNR, CONISMA and University of Pavia until 2017; Unclear since 2018	ISPRA		
Malta	University of Malta	University of Malta		
Slovenia	Ministry of the Environment and Spatial Planning;	Ministry of the Environment and Spatial Planning	yearly	

	Slovenian Environment Agency; Institute for Water of the Republic of Slovenia.		
Spain	MITECO, IEO, CTN	MITECO	Yearly or as determined by RSC

5.4 Future indicators: exploring risk-based approaches

It is generally pointed out that the crude calculation of pulse-block days, and the related spatial and temporal proportions, are poor predictors of the impact of noise on the marine environment, and therefore of the environmental status of a sea area. Nonetheless, Commission Decision 2017/848 requires EU Member States to establish thresholds values to ensure that levels of anthropogenic noise do not exceed levels that adversely affect populations of marine animals. Considering the existing knowledge gaps, initiatives are underway to provide a better framework for assessing the status of the environment about marine noise pollution and make it easier for regulator to set thresholds and practical environmental targets. Recent work deals with combining the spatial representation of noise (or noise sources) with biological information.

Three examples are described hereafter:

1. Marine Noise Budgets in Practice(Merchant et al., 2017), proposing a framework of noise exposure indicators based on biological risk for marine species.
2. *Modelling sound and disturbance maps using the impulsive noise register for assessing cumulative impact of impulsive sound* (von Benda-Beckmann et al., 2017), proposing a framework to assess the disturbance to marine wildlife of modelled sound field from impulsive noise sources.
3. *Modelling underwater sound fields from noise events contained in the ACCOBAMS impulsive noise register to address cumulative impact and acoustic pollution assessment* (Drira et al., 2018), illustrating a similar framework than the previous point for assessing the potential impact of noise radiated from sources contained in the Noise Register on marine species.

In the three examples above noise maps are derived using data from noise registers but they differ in the way noise maps are derived. Merchant and co-authors calculate *percentages duration*, in terms of pulse-block days, over the time window of interest (total number of pulse-block days of the time window, in percentage). Instead, von Benda-Beckmann and co-authors and Drira and co-authors use sound propagation modelling to calculate noise footprints, i.e. the areas where received levels exceed relevant noise exposure thresholds, and then calculate how many days such thresholds were exceeded over a year, thus obtaining an impact indicator (called *disturbance days* by von Benda-Beckmann and co-authors).

With regards to biological and ecological information, the assessment frameworks outlined in the three examples presented before address the use of population density data to assess the overlap degree between noise and presence of species, and finally derive an impact indicator.

However, only the methodologies based on sound propagation modelling allow applying sound exposure criteria and hence derive maps showing the different areas of noise influence. This fact would allow avoiding the use population density data, while still providing information on potential impact on target species and hence meeting the definition of D11C1 contained in the Commission Decision 2017/848).

A fourth initiative having the aim of improving the current units of measurements (pulse-block days) is presented here, as developed by CTN. This new indicator is calculated for each point of the assessment area (i.e. each cell of a spatial grid) and the calculation includes the source level of all noise sources surrounding the assessed grid cell, the distance from the source and the number of days of use over the assessment period. In this indicator, the starting point is therefore the calculation of pulse-block days in the spatial grid. But the calculation is done also for the cells where pulse-block days is 0, because this indicator considers the noise sources that may be active around the assessed cell, thus accounting somehow with the fact that sound propagates out of the grid cell limits used today by ICES and ACCOBAMS. The equation of this indicator (called Acoustic Level, AL) is applied to each point (P) of the assessment grid and is outlined below:

$$AL(P) = 10 \cdot \log\left(\sum_{i=1}^{N} 10^{\left(\frac{L_{0i}}{20}\right)} \cdot \left(\frac{n}{Nd} t\right) \cdot \frac{1}{r_i}\right)$$

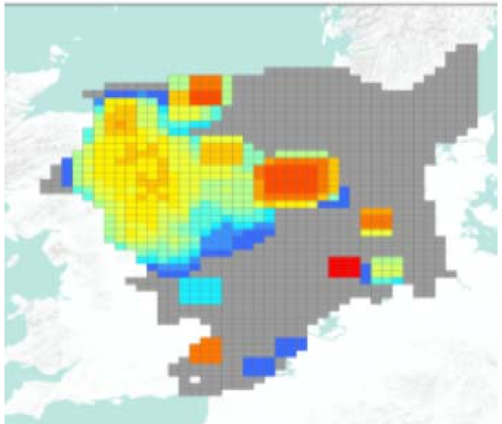
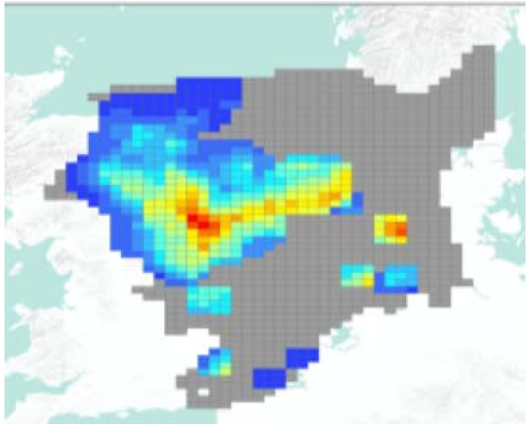
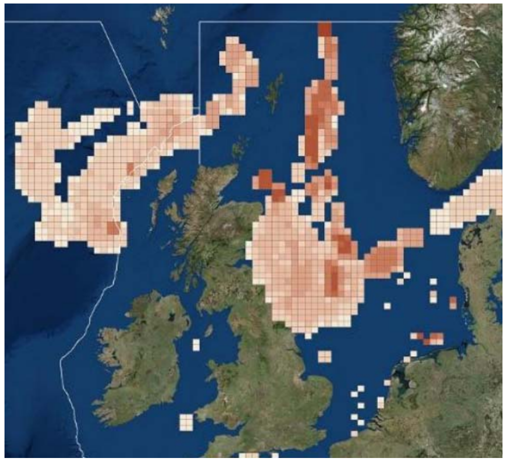
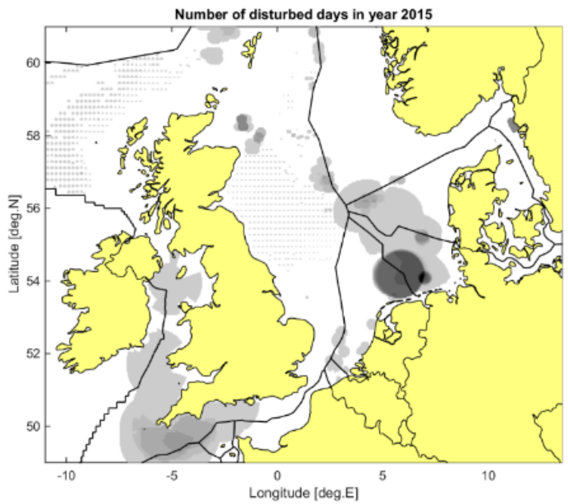
Where:

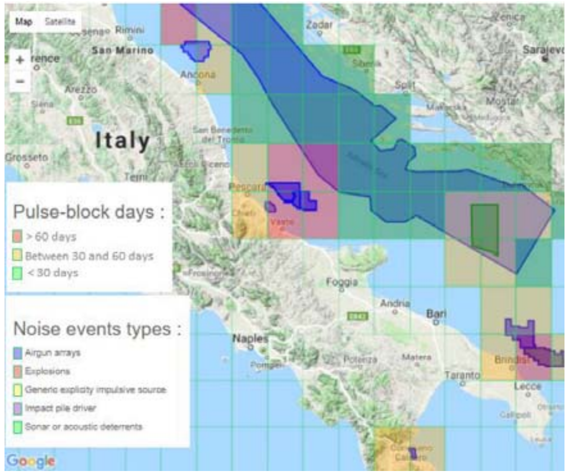
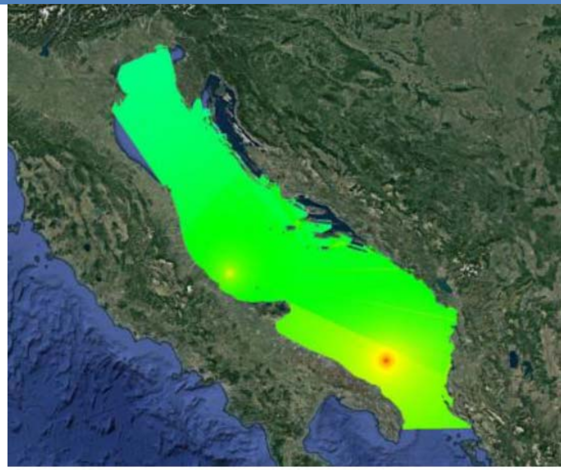
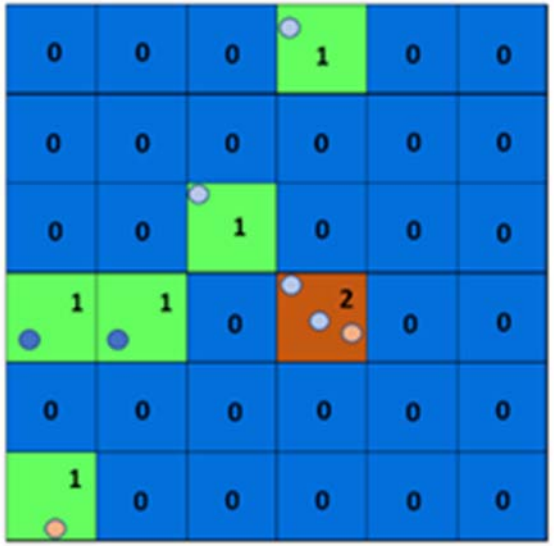
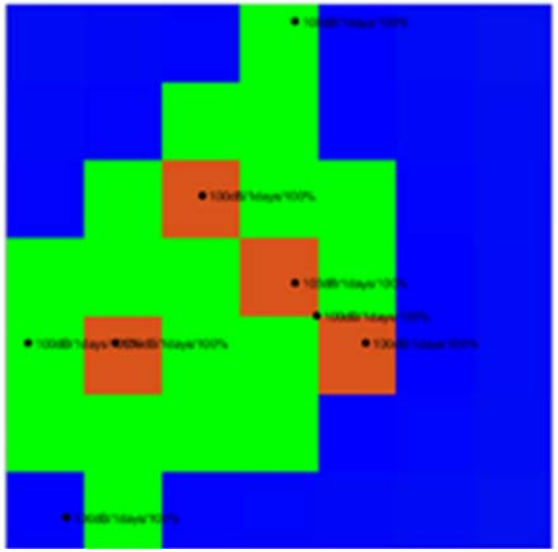
- N is the total number of acoustic sources
- N_d is the number of days in the considered time period
- L_0 is the sound pressure level of the source [dB]
- n is the number of days the source is used.
- t is the daily duty cycle of the source [%]
- r is the distance from the source to the point grid P [km]

However, this proposal is at an early stage of development and further effort is required to define in detail how the calculation is done and better assess its aplicability (since data on duty cycle and precise SLs are required). Furthermore, although a better consideration of the acoustic properties of noise is proposed, this method currently does not address how it could support the definition of meaningful thresholds and/or help the management of underwater noise pollution from a practical point of view.

Summarising, the point worth noting here is that all methods described in this chapter propose improvements of the current framework (based on the pulse-block days). Whereas it is not the scope of this document to find and/or recommend the best approach, the proposed improvements are represented and compared in the following table (Table 2).

Table 2. Comparison of proposed improvements proposed by the initiatives described in this chapter.

Source	Pulse-block days	Proposed new approach	Description
Merchant et al., 2017			The map on the right is derived overlapping the map on the left on a harbour porpoise distribution layer. It shows that priority areas for management may be different than hotspots on the pulse-block day maps.
Von Benda-Beckmann det al., 2017			The map on the rigth is based on propagation modelling applied to noise events on the left map, and on disturbance thresholds for harbour porpoise. It shows that the largest disturbance areas are located where less noise source hotspot are found in the pulse-block day map.

Source	Pulse-block days	Proposed new approach	Description
Drira et al. 2018			The work from Drira et al focusses on showing the extension of the influence area of an impulsive noise source compared to the limits of the currently used spatial grid systems for pulse-black day representation. This fact is at the basis of the calculation of an impact indicator as presented in von Benda-Beckmann (2017)
CTN (unpublished data)			Again, the work from CTN shows an extended area under concern (on the rigth) compared to the pulse-block day map computed using the method currently used for existing noise registers.

6 Annex

6.1 Using the *pulse-block days* metric for criterion calculation (D11C1)

The TG-Noise recommended metric for the impulsive noise indicator is pulse-block days, i.e. the number of days that a certain threshold (pulse) is exceeded in an area (block), for a calendar year (Dekeling et al., 2014). It is noteworthy that the number of pulses occurring in a given block in a single day is not relevant for the computation of the indicator value, which is 1 for such a case, regardless of the number of pulses. In practice, in the case of a noise source emitting several times in the same day (e.g. an airgun for seismic surveys, or during a piling work), or where two or more noise sources are emitting in the same block in the same day, the computation results in 1 pulse-block day, for that day and that block.

The pulse-block-days metric appears simple and straightforward to implement. The procedure to get the indicator value consists simply in locating the activities that used noise sources and calculate how many days the noise sources were used. This calculation is done over a regular spatial grid and the result is a hotspot map as describe in the chapter 3 of this document. This metric is currently used in the noise register for the OSPAR and HELCOM regions.

It is worth considering here again the Commission Decision 2017/848 of 17 May 2017, and the units of measurement indicated for D11C1, reported hereafter:

"the number of days per quarter (or per month if appropriate) with impulsive sound sources; proportion (percentage) of unit areas or extent in square kilometres (km²) of assessment area with impulsive sound sources per year".

These definitions update and modify somehow the definitions given for D11 implementation in the previous Commission Decision 2010/477. As such, they do not appear unambiguous, especially concerning how the *pulse-block days* metric fits the new definitions of "*days [...] with impulsive sound sources"* and "*[area] with impulsive sound sources"*. Therefore, interpretation appears necessary to solve this ambiguity. In this document, it is proposed that the basis for disambiguation is the work carried out by TG-Noise in the past years (Dekeling et al., 2014, 2013; Van der Graaf et al., 2012). Therefore, "*days with impulsive sound sources*" can be interpreted as simply *pulse-block days*, as defined by Dekeling and co-authors (2014). Hence, the first part of the definition above could be understood as:

- The number of pulse-block days per quarter (or per month if appropriate), in the assessment area (region, subregion, or subdivision);

Further, "*[area] with impulsive sound sources"* can be interpreted as [area] with at least 1 pulse-block day. Hence, the second part of the definition above could be:

- The proportion (percentage) of unit areas (grid cells) or extent in square kilometres (km²) of assessment unit (region, subregion, or subdivision) with at least 1 pulse-block day, per year

With these clarifications, the use of pulse-block days for the measurement of the spatial and temporal distribution of impulsive noise sources appears appropriated.

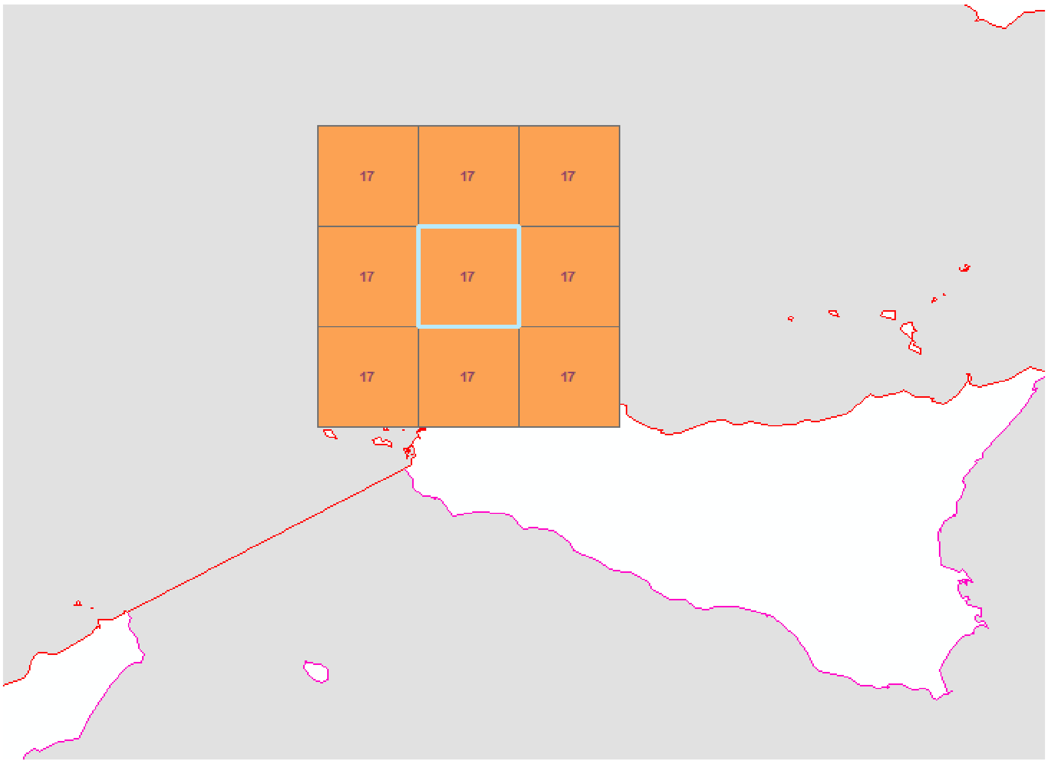
6.2 Solving issues related to the use of GIS in criterion calculation (D11C1)

D11C1 calculation takes into consideration spatial functions to assign D11C1 calculated value to the right cell. The spatial lookup must select the correct cell of the GFCM grid where noise events are located whatever the reporting unit uploaded. In first instance, the spatial *intersects* function seems to be the best option to achieve the aim of the project. In case of ICES impulsive noise register this is the spatial function used for the calculation of the pulse-block day (PBD). The *intersercts* function finds geometries that crosses between them, so this might work to this case.

However, the *intersects* function takes into consideration the intersection of the boundaries between cells too. This issue can give innacuracy in D11C1 calculation because polygons are drawn by excess. This means grid cells where no noise is reported are drawn in the map (See Figure 18). This issue can produce over-estimation of the D11C1 criterion.

If *intersect* spatial function is used to D11C1 calculation the over-estimation can ocurr in the following situations:

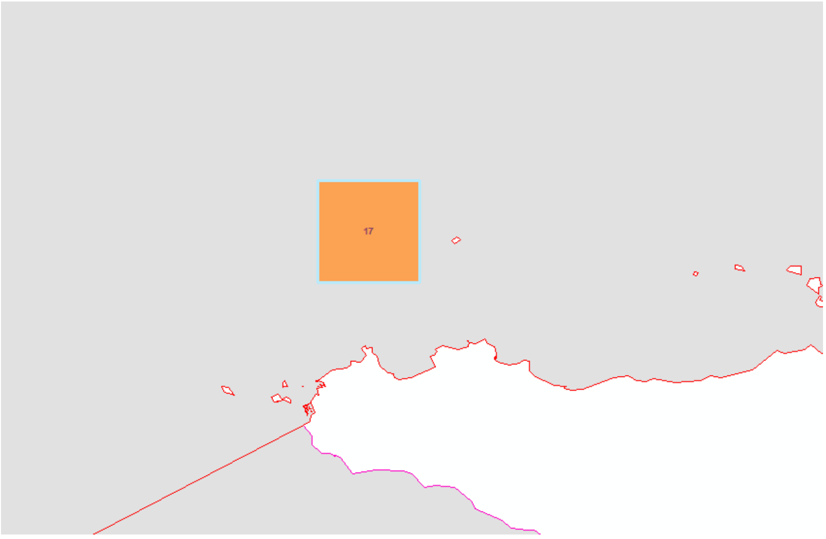
- When the grid used to report noise events is the same than the grid used for D11C1 criterion calculation (Case of use of GFCM grid to report noise events). In this case, if 17 pulse-block days are reported for a grid cell (Picture 18, central cell), and the *intersect* spatial function is used for D11C1 calculation, the result is the next:



Picture 19. D11C1 calculation with GFCM grid as reporting format: case of *intersect* spatial function (non-real data)

As can be seen in Picture 18, the *intersects* spatial function take into consideration the neighbouring cells (orange cells) to calculate D11C1 criterion, while the GFCM grid cell used to report noise events is only 1 (central cell in light blue border).

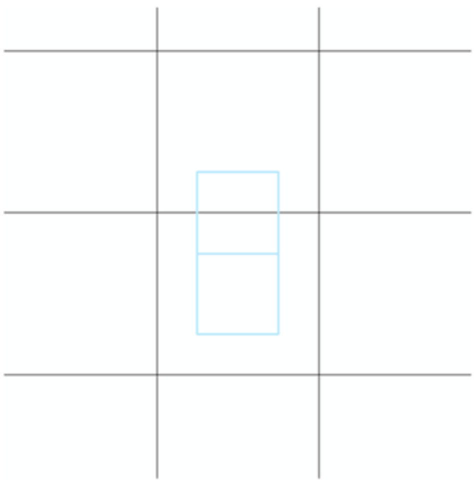
In this case, to avoid this over-estimation the *equals* spatial function will be used. The *equals* spatial function takes into consideration the geometries that are exactly the same as the geometry used as data entry. An example is shown in Picture 19:



Picture 20. Example of D11C1 calculation using cells of GFCM as reporting format and *equals* spatial function instead of *intersect* (non-real data).

As shown in Picture 19, the use of the same grid (GFCM) for D11C1 calculation and for data reporting does not creat any problem when the *equals* function is used.

- When the grid used to report noise events is a regular grid different to the GFCM grid (case of use national grids to report noise events). The over-estimation could can ocurr again as we may have cells of national grids that are inside cells of GFCM grid and cells that crosses different GFCM grid cells (Picture 30).

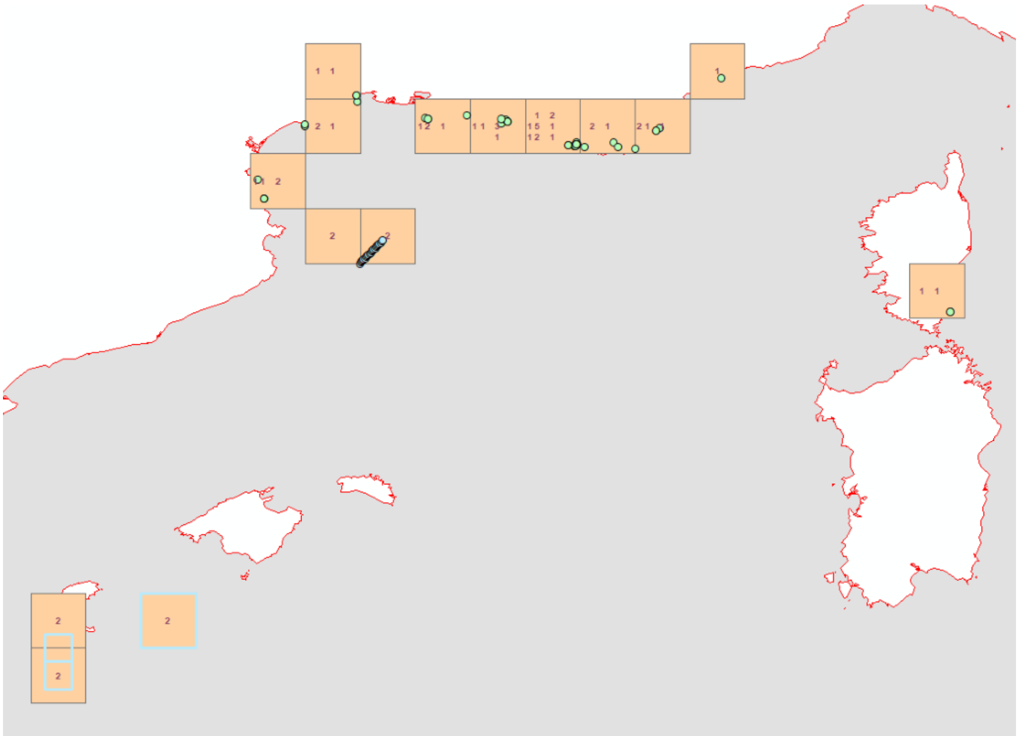


Picture 21. Grid used by SHOM (France) in light blue, crossing and contained in GFCM grid (black).

In this case, if the *intersects* spatial function is applied, as explained before, some problems can ocurr when boundary of national grids match with boundary of GFCM grid cells. *Equals* spatial function cannot be applied in this case because the geometries of the national grids are different to the geometries of the GFCM grid. Other spatial functions can be considered (*within, contains_properly, overlaps…*) but nothing fit to this case. For this specific case there isn't a spatial function that adapt to this problem, so, the best way to select the adequate cells of GFCM grid to apply D11C1 calculation is a composite of spatial functions.

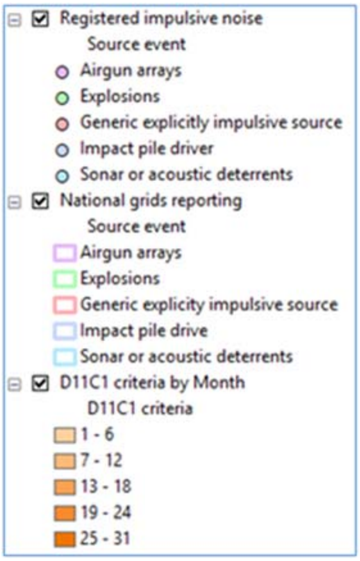
The solution is to apply in first instance, the *contains* spatial function. This spatial function aims to find the geometries that are inside of the given geometry. This function can find national grid geometries inside GFCM grid, so when a national grid cell is contained in a GFCM cell the spatial function can determine the adequate grid cell to apply D11C1 calculation. But when a national grid is crossing GFCM grid geometries the *contains* spatial function takes no effect. In this case *intersects* filter can be applied successfully to select the GFCM grid cells that crosses with a national grid.

The result to apply the mentioned spatial functions in the INR-MED are:



Picture 22. General overview of D11C1 calculation in GFCM grid cells (preliminary calculation on non-real data)

In view of all these issues, the overestimation generated by the intersection between boundary cells during D11C1 calculation produce wrong results in terms of precision. It is important, then, avoid the inclusion in D11C1 calculation of cells that really do not have associated a reporting unit to it.



Picture 23. INR-MED legend

6.3 MSFD Marine Region Vertex simplification

The marine regions and subregions map and correspondent layers provide information about the geographic boundaries of the areas listed in Article 4 of the Marine Strategy Framework Directive (MSFD). The map has been developed to support DG Environment and EU Member States in their implementation of the MSFD. It represents the current state of understanding of the marine regions and subregions and is subject to amendment in light of any new information which may be produced.

During noise register development it was found a problem with the large amount of vertex of the MSFD Marine Regions spatial files. These layers caused overloads when were requested in the map interface incrementing the waiting times for simple operations. To solve this problem was proposed a simplification of vertex of the marine subregion layer. The marine subregion layer was selected to do the simplification because is the layer that is causing the overload problem when is loaded in the map. This layer is used to represent the Mediterranean Sea and the Black Sea regions apart from their respective subregions.

The methodology for vertex simplification takes in consideration GIS analysis. Firstly, coastline of the marine subregion layer was analyzed to determine the better tolerance to be applied in the deletion of the vertex, the analysis of coastline was realized only in significance areas due to the large number of meters of coastline in the Mediterranean Sea area. The tolerance determines the simplification degree, the specified tolerance is the maximum allowable offset. How much bigger is the tolerance value the vertex simplification is bigger too. After the analysis of the significant areas the tool *Simplify Polygon* of ArcMap was used to reduce the quantity of vertex of the marine subregion layer. The algorithm used for the simplification was the POINT_REMOVE that Keeps the so-called critical points that depict the essential shape of a polygon and removes all other points.

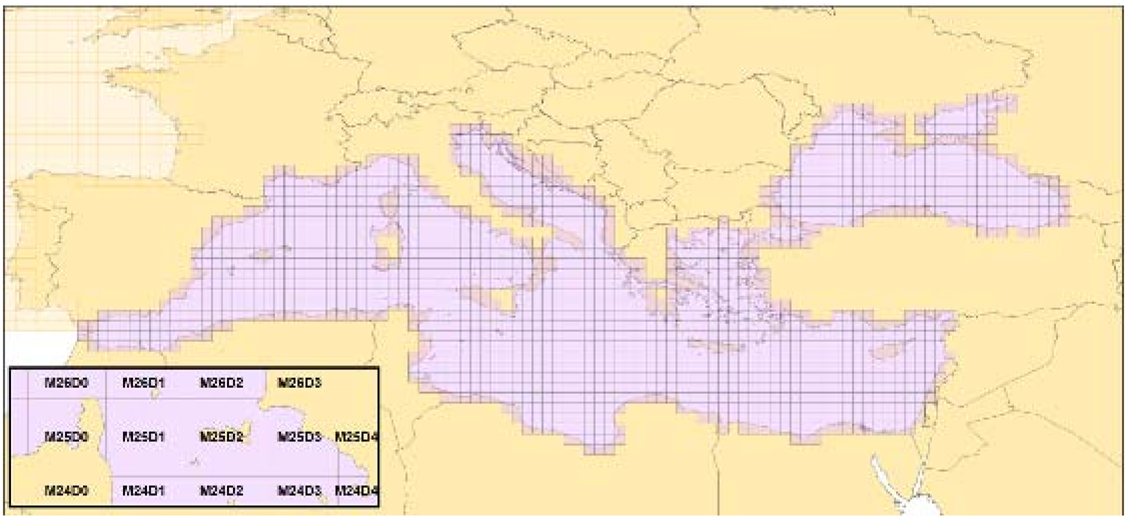
It is important to consider that the polygon simplification do not works well for all areas of the marine subregions because the coastline can vary his shape along its length, so the simplification works better for the coastline areas that were analyzed in the first step. Besides, the vertex simplification modifies the coastline, this causes a mismatch between simplified marine subregions layer and basemap layer. This problem can be significant in visualization when the map scale is too big because coastline differences are perceived bigger.

The proposed solution was hide the marine subregion layer in the map interface when the map scale is bigger than a predefined value set in the map service provided by ArcGIS for Server, because in low scales differences in the coastline definition between simplified vertex of the marine subregion layer and the basemap layer are not appreciable.

It should be pointed out that loss of precision obtained after simplification do not affect the precision of the application regarding to the computing tasks (calculating D11C1, checking location of reported event…) because the high precision marine subregion layer is used too for the application when is needed provide reliable results.

6.4 GFCM grid and coding system

The codification of a rectangle in the GFCM statistical grid is a 5 digits' code: (i) Latitude is covered by a composed 3-digits code of a letter (M) and a number (Table 7). Maximum range from M00 (30°N) up to M34 (47°30'N); (ii) Longitude is covered by a composed code of a letter and a number (Table 8). The letter range is from A to J and number range per letter is from 0 to 9. Maximum range from A0 (6°W) up to J5 (42°E). Figure 13 presents an overview of the grid.



Picture 24. GFCM grid in the Mediterranean and Black Sea with an example of the coding system for the northern Tyrrhenian Sea6. This picture shows also the ICES statistical rectangles in the Atlantic (yellow cells).

Table 3 Coding for Latitudes. All values are in decimal degrees (WGS84) in the Northern hemisphere (all positive values).

CODE	FROM	TO
M00	30	30.5

M01	30.5	31
M02	31	31.5
M03	31.5	32
M04	32	32.5
M05	32.5	33
M06	33	33.5
M07	33.5	34
M08	34	34.5
M09	34.5	35
M10	35	35.5
M11	35.5	36
M12	36	36.5
M13	36.5	37
M14	37	37.5
M15	37.5	38
M16	38	38.5
M17	38.5	39
M18	39	39.5
M19	39.5	40
M20	40	40.5
M21	40.5	41
M22	41	41.5
M23	41.5	42
M24	42	42.5
M25	42.5	43
M26	43	43.5
M27	43.5	44
M28	44	44.5
M29	44.5	45
M30	45	45.5
M31	45.5	46
M32	46	46.5
M33	46.5	47
M34	47	47.5

Table 4 Coding for Longitudes. Values are in decimal degrees (WGS84). Negative values mean West coordinates.

CODE	FROM	TO
A0	-6	-5.5
A1	-5.5	-5
A2	-5	-4.5
A3	-4.5	-4
A4	-4	-3.5
A5	-3.5	-3
A6	-3	-2.5
A7	-2.5	-2
A8	-2	-1.5
A9	-1.5	-1
B0	-1	-0.5
B1	-0.5	0
B2	0	0.5
B3	0.5	1
B4	1	1.5
B5	1.5	2
B6	2	2.5
B7	2.5	3
B8	3	3.5
B9	3.5	4
C0	4	4.5
C1	4.5	5
C2	5	5.5
C3	5.5	6
C4	6	6.5
C5	6.5	7
C6	7	7.5
C7	7.5	8
C8	8	8.5
C9	8.5	9
D0	9	9.5
D1	9.5	10
D2	10	10.5
D3	10.5	11

D4	11	11.5
D5	11.5	12
D6	12	12.5
D7	12.5	13
D8	13	13.5
D9	13.5	14
E0	14	14.5
E1	14.5	15
E2	15	15.5
E3	15.5	16
E4	16	16.5
E5	16.5	17
E6	17	17.5
E7	17.5	18
E8	18	18.5
E9	18.5	19
F0	19	19.5
F1	19.5	20
F2	20	20.5
F3	20.5	21
F4	21	21.5
F5	21.5	22
F6	22	22.5
F7	22.5	23
F8	23	23.5
F9	23.5	24
G0	24	24.5
G1	24.5	25
G2	25	25.5
G3	25.5	26
G4	26	26.5
G5	26.5	27
G6	27	27.5
G7	27.5	28
G8	28	28.5
G9	28.5	29

H0	29	29.5
H1	29.5	30
H2	30	30.5
H3	30.5	31
H4	31	31.5
H5	31.5	32
H6	32	32.5
H7	32.5	33
H8	33	33.5
H9	33.5	34
I0	34	34.5
I1	34.5	35
I2	35	35.5
I3	35.5	36
I4	36	36.5
I5	36.5	37
I6	37	37.5
I7	37.5	38
I8	38	38.5
I9	38.5	39
J0	39	39.5
J1	39.5	40
J2	40	40.5
J3	40.5	41
J4	41	41.5
J5	41.5	42

6.5 Excel template for data reporting from Member-States

This annex reports the name of fields that are part of the data form and describes the content of such fields. The form (an Excel template) is made of 4 worksheets:

- Instructions_Export
- File information
- Noise register data
- Vocabularies

Data on noise events are to be entered in the "noise register data" worksheet (Table 5). Additional information are to be entered in the "file information" worksheet concerning the preparation of the form: what country, what organization in that country, and preparation date (Table 6). The worksheet called "Instructions_Export" shall provide instruction on filling the data form and on how to upload it in the register web portal, while the "vocabularies" worksheet will present available options for multi-option fields.

Table 5. Worksheet *noise_register_data*

Column	Field	Content	Type
A	data_entry_point_ID	String	Mandatory
B	start_date	ddmmyyyy	Mandatory
C	end_date (ddmmyyyy)	ddmmyyyy	Mandatory
D	Latitude	Decimal degrees WGS84	Mandatory
E	Longitude	Decimal degrees WGS84	Mandatory
F	Geometry_type	Point, GFCM Grid, National Grid, other grid system	Mandatory
G	polygon_ID	GFCM sub-rectangle ID, National block ID or spatial object filename	Mandatory
H	source_event	Airgun arrays/Explosions/Pile driving/ Sonar or acoustic deterrent/Generic noise source	Mandatory
I	value_code	NA/very_low/low/medium/high/very_high	Mandatory
J	sound_mitigation_bool	Yes/no	Mandatory
K	data_quality	1 to 4	Mandatory
L	NMS_type	Type of noise mitigation system (from list provided in the vocabularies worksheet / ACCOBAMS Resolution 4.17)	Optional
M	sound_measurement_bool	yes/no	Optional
N	SEL	Sound Exposure Level expressed as dB re 1μPa²s	Optional
O	Lpeak	Zero-to-peak level expressed as dB re 1μPa	Optional
P	distance_to_pile	Decimal metres	Optional
Q	type_hammer	Model number of hammer used, e.g. S-2000, 3000S	Optional
R	max_energy	Kj	Optional
S	source_spectra	Units to be determined	Optional
T	duty_cycle	Decimal	Optional
U	start_time	hhmm	Optional
V	duration	seconds, integer	Optional
W	directivity	decimal	Optional
X	source_depth	metres, decimal	Optional
Y	platform_speed	knots, decimal	Optional
Z	Remarks	Free text	Optional

Table 6. Worksheet file_*information*

Column	Field	Content	Type
A	Country	ISO 1366 code from list provided	Mandatory
B	Preparation Date	ddmmyyyy	Mandatory
C	Organization	EDMO code from list provided	Mandatory