Bases para la planificación sostenible de áreas marinas en la Macaronesia

Activity 2.1.2. Pilot Zoning - Developed Methodology

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1 Introduction

In recent decades the EU has acknowledged the importance of the Oceans and defined a Blue Growth strategy to support the sustainable growth of maritime activities (EC, 2012; EC, Annex 2014). With the adoption of the Integrated Maritime Policy (IMP), Europe seeks to improve synergies among maritime activities and marine environment. The IMP is a set of cross cutting policies that includes the promotion of the roadmap on Maritime Spatial Planning (MSP). Promoting Blue Growth via MSP is highly interlinked with the spatial criteria and requirements for the ocean space as set by different maritime sectors. MSP can facilitate the development of these Blue Growth sectors in a context of increasing competition for space and limited ecosystem resources applying zoning techniques, that follows ecosystem approach, based on the scientific data and information. **Zoning is an essential part of MSP that can facilitate conservation of the marine environment, protect biodiversity and finally reduce conflicts with coastal and maritime activities, technique supported by scientific knowledge and required spatial data and information**.

This study was delivered by researchers linked to the Project PLASMAR (MAC/1.1a/030) with the support of the European Union (EU) and co-financed by the European Regional Development Fund and the INTERREG V-A Spain-Portugal MAC 2014–2020 (Madeira-Azores-Canarias). **Zoning methodology is delivered for potential introduction of new maritime activity or expanding already operational sectors** within the Macaronesia. The results of the entire project as well as 4 years of studies covering data collections, monitoring, analyses, method components & tools development, and finally process & results testing for pilot zoning of marine areas are summarized in this technical report.

During the last years theoretical **Blue Growth studies on sustainability**, including exhaustive review on the environmental issues, pressure solutions and impact mitigation for **aquaculture, fisheries, maritime transport and offshore wind energy[1]** maritime sectors were finalized These studies identified which are the relevant environmental parameters that need to be considered within the Maritime Spatial Planning zoning processes, following the **Marine Strategy Framework Directive** 20008/56/EC (MSFD), Good Environmental Status (including 11 quality descriptors and 42 related criteria elements) (GES) per each analyzed sector.

Subsequently, relevant parameters of the marine environment, including **marine conservation**, **physical oceanography, land sea interactions and potential conflicts with coastal and maritime sectors**, were identified in association with each analyzed maritime sector.

Furthermore, a **Decision Support System (DSS)** tool - **INDIMAR** - was developed for facilitating maritime sector zoning. Collected maritime and environmental data as well as spatial information was included in the INDIMAR tool. Thus, the model run by INDIMAR provided zoning analyses per each analyzed sector, based on:

1. **Environmental sensibility**, following the MSFD GES checklist;
2. **Marine Protected Areas** locations and conservation targets;
3. **Oceanographic** limiting parameters;
4. **Land sea interactions**, including analysis of **potential conflicts coastal sectors**
5. Analysis of **potential conflicts with maritime operative sectors**.

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[1] Available on the www.plasmar.eu , products section, 2.1.1. c&d technical reports

To integrate and superpose developed analyses, a "weights" system was used that defined significance of each parameter within the cluster framework. **Weights profile were calculated following the methodological approach of the Analytical Hierarchy Process** (AHP).

The different steps described in the above paragraphs are key elements of the developed methodology for zoning activities/sectors over the maritime space, following the principles of Maritime Spatial Planning and applying an ecosystem approach. The developed methodology was tested for offshore wind energy, aquaculture and mineral (sand) extraction maritime sectors within the Azores, Madeira and Canary Islands.

2 The partners of the PLASMAR Project provided the marine / maritime expertise linked to zoning of marine areas for the Macaronesian archipelagos, namely:

- Gestión del Medio Rural de Canarias, S.A.U. (Canary Islands, Spain),
- Direção Regional dos Assuntos do Mar (Madeira, Portugal),
- Agência Regional para o Desenvolvimento da Investigação, Tecnologia e Inovação (Madeira, Portugal),
- Secretaria Regional do Ambiente e dos Recursos Naturais (Açores, Portugal),
- Universidade dos Açores (Açores, Portugal),
- Universidad de Las Palmas de Gran Canaria, Instituto Universitario ECOAQUA (Canary Islands, Spain).

3   Results

3.1   Data collection - PLASMAR MSP data framework

Due to the diversity and somethings complexity to gather the overall marine / maritime data necessary to develop zoning exercises and analysis, it was necessary to create within PLASMAR project a MSP Data Framework in order to collect data more efficiently, avoid unnecessary or useless collected datasets and make (spatial) information manageable (Figure 1). Compulsory data sets were divided into five clusters: Data on marine environment according to the Good Environmental Status (GES) of the Marine Strategy Framework Directive 2008/56/EC (MSFD); Spatial data and information on Marine Protected Areas (MPA's); Physical oceanography datasets; Coastal Land use and information on Current Maritime Activities.
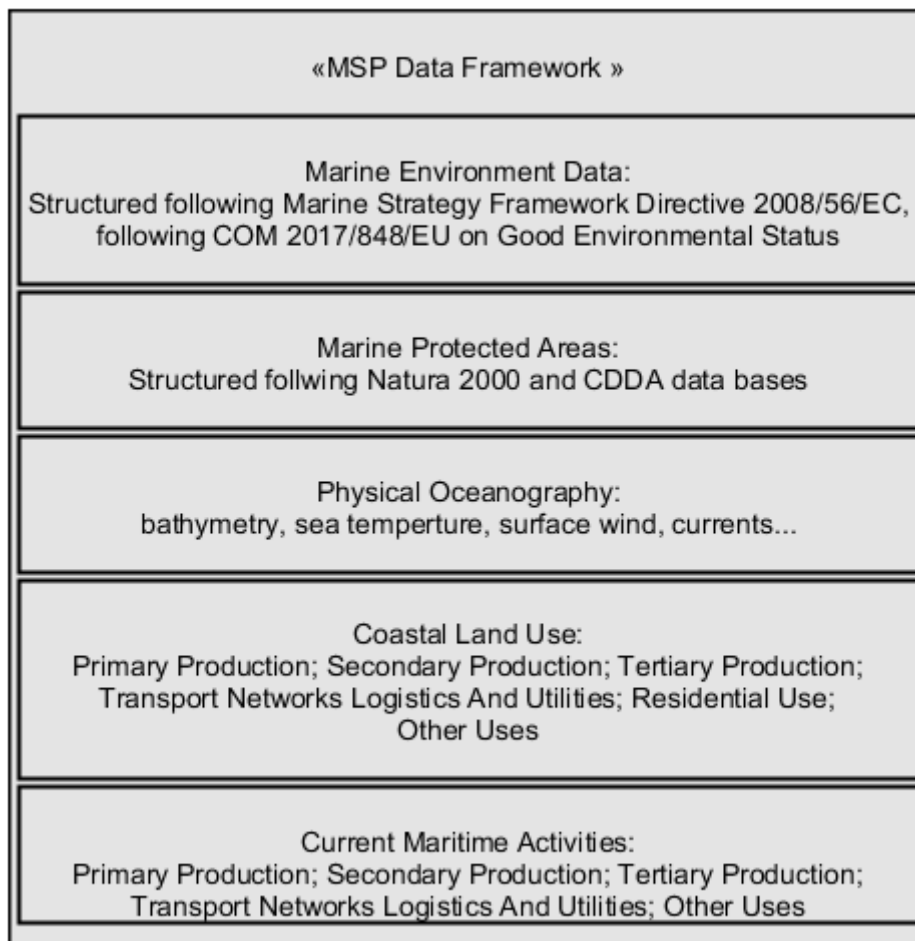
«MSP Data Framework »

Marine Environment Data:
Structured following Marine Strategy Framework Directive 2008/56/EC, following COM 2017/848/EU on Good Environmental Status

Marine Protected Areas:
Structured follwing Natura 2000 and CDDA data bases

Physical Oceanography:
bathymetry, sea temperture, surface wind, currents...

Coastal Land Use:
Primary Production; Secondary Production; Tertiary Production; Transport Networks Logistics And Utilities; Residential Use; Other Uses

Current Maritime Activities:
Primary Production; Secondary Production; Tertiary Production; Transport Networks Logistics And Utilities; Other Uses

Figure 1 - MSP Data Framework applied with PLASMAR project

3.2 Relevant parameters selection

The collected parameters were classified by PLASMAR experts based on its significance within each analyzed maritime sector and following exhaustive reviews of the available science & technical knowledge (peer-reviewed papers, technical reports of scientific committees, EU & UNESCO technical reports, etc.).

Analysis of the relation of each parameter to the different maritime sectors have been done following the methodological frame summarized in Table 1. The main argument behind it, was to reduce complexity (as discussed during the Madeira Workshop – 3rd PLASMAR face-to-face meeting, please check workshop's report in project's website), include positive/negative impact & contribution logic, but **not over model** (maintain on feasible level of detail). Level of modelling depends on data availability and increasing level of details significantly escalate complexity of the task (e.g. MPA's can be affected by aquaculture facilities, and aquaculture can be affected by MPA, but as the first relation was considered as more relevant, it was included in the final model of zoning). It was agreed, that model can be updated later with relations that were excluded from this first version.

Table 1 - Relationships of defined cluster and maritime activities

MSFD Good Environmental Status criteria elements	**How maritime activity affects environmental (GES) parameters** It has to be analyzed how Maritime activity affects the environmental parameters that are defined with MSFD GES (e.g. how aquaculture affects habitat, if positive and negative, it is needed to explain how and on which type of habitat "impact" is positive and on which type of habitat is negative.
MPA	**How maritime activity affects to MPA's** It has to be analyzed how Maritime activity affects the MPA's, and if possible to have maritime activity operational within the MPA. Again we need to define this in type of the MPA'a (IUCN classification and NATURA 2000 targets)
Land use/cover	**How Planned Land use parameters affects Maritime activity** It has to be analyzed how activities on the coast can affect maritime activities. Land use will not be possible to include, so we will need to include only classification of the CORINE (Land cover) It has to be analyzed how distance can affect maritime activity. (can be divided in ranges) It has to be analyzed how point and lineal pressures can affect maritime activity. (will be divided on type of pressures – submarine outfall, outfall...)
Oceanography	**How Oceanography parameters affects Maritime activity** If do usually is positive and negative. Need to be explained and if possible established values for which maritime activity is positively affected and for which values is negatively affected, including restrictions (e.g. aquaculture is positively affected by average temperature >15°; but negatively affected <15°. Aqauculture is impossible in area with average temp >25° and <10)
Maritime activities	**If maritime uses can co- exist/compatibile with analyzed maritime activity.** This is analysis on possible co-use , co-existence and exclusions. Please apply reality not future potential concepts (as co-use of offshore wind and aquaculture facilities)

3.2.1 MSFD Good Environmental

How maritime activity affects environmental (GES) parameters?

It was analyzed how maritime activity affects the environmental parameters that are defined within MSFD GES (e.g. how aquaculture affects benthic habitat, if positive and/or negative, it is needed to understand how and on which type of habitat "impact" is positive and on which type of habitat is negative):

· Descriptor 1. Biodiversity – Habitats and Species
· Descriptor 2. Non-indigenous species
· Descriptor 3. The population of commercial fish species
· Descriptor 4. Elements of food webs
· Descriptor 5. Eutrophication – Chlorophyll *a*, dissolved oxygen, salinity, nutrients (aggregated data, not time series)
· Descriptor 6. The sea floor integrity
· Descriptor 7. Permanent alteration of hydrographical conditions
· Descriptor 8. Concentrations of contaminants – heavy metals and other contaminates - aggregated data, not time series
· Descriptor 9. Contaminants in seafood - aggregated data, not time series
· Descriptor 10. Marine litter
· Descriptor 11. Energy, including underwater noise data

In the case of **offshore wind energy, aquaculture, fisheries and maritime transport** maritime sectors specific studies were developed, following **GES check list (42 criteria elements)**, considering relevant environmental issues, pressures reduction, impact mitigation and applicable monitoring methods. These detail reports on maritime sectors environmental issues (2.1.1 project Plasmar activity) and potential solutions are available in the products section of the project's website (www.plasmar.eu).

3.2.2 Marine Protected Areas (MPA's)

How maritime activity affects MPA's?

It was analyzed how the different maritime activity affects MPA's as well as the possibility to have certain maritime activity operational within the marine conservation area. For this analysis was necessary to classify MPA's according to IUCN classification and NATURA 2000 targets. The reported data used were those shared by European Environment Agency on nationally designated areas **CDDA and Natura 2000** databases. These datasets were mapped into IUCN protected area classification, and grouped by conservation targets.

3.2.3 Land Use parameters – terrestrial coastal activities

How coastal Land use affects maritime activity?

It was analyzed how anthropogenic activities on the coast may affect maritime activities and if there is any potential conflict. Land use data was not available, but included CORINE (Land cover) classification. **CORINE Land cover classification**: urban areas, industrial areas, beaches, dunes…, were comprised in the zoning exercise. It was analyzed how CORINE coastal activities/elements could be considered for land-sea interactions analysis. Additionally, it was analyzed how each maritime activity could be affected by distance from the shore.

3.2.4 Physical oceanography parameters

How oceanography parameters affect maritime activity?

Listed oceanography parameters can be limiting for the maritime activity and in operative ranges can have a positive or a negative effect. It was analyzed which oceanography parameters are relevant, and if so, what are the value ranges that restrict activity, and value ranges that have positive/negative effect (e.g. aquaculture is positively affected by average temperature >20°; but negatively affected <20°; or aquaculture is not feasible in areas with average temp <18°):

- Temperature (time series & statistics)
- Currents (time series & statistics)
- Waves (time series & statistics)
- Depth / Bathymetry
- Wind (time series & statistics)

3.2.5 Maritime activities/pressures:

How current maritime uses affects analyzed maritime activity'

We did an analysis on possible co-use, multi-use, and considering also exclusions areas. This analysis was applied on current reality, not future potential concepts, that is, considering only the extant maritime sectors:

- Point pressures
- Harbours / Ports
- Aquaculture facilities
- Maritime traffic lanes
- Fisheries areas
- Cables
- Maritime tourism
- Military area
- Research Area

- Seaweed cultivation
- Nautical sports
- Wrecks
- ...

The relevance of each parameter, in the zoning exercise, related to the specific maritime sector was classified as "low", "medium" and "high", and only the classifications "medium" and "high" were included in further study .

3.3   Decision Support System INDIMAR

All collected data were introduced into INDIMAR, the spatial data Decision Support System (DSS) tool for sectorial zoning and MSP purposes. In the framework of the PLASMAR project, the DSS INDIMAR tool was designed by the ECOAQUA Research Institute as a Geographical Information System (GIS) web application, and its intellectual property is protected under Safe Creative license.

The Macaronesia archipelagos areas were divided in a mesh based on 10" arc square cells (300 m aprox.). Each cell includes encoded spatial information, following MSP Data Framework (Figure 1).
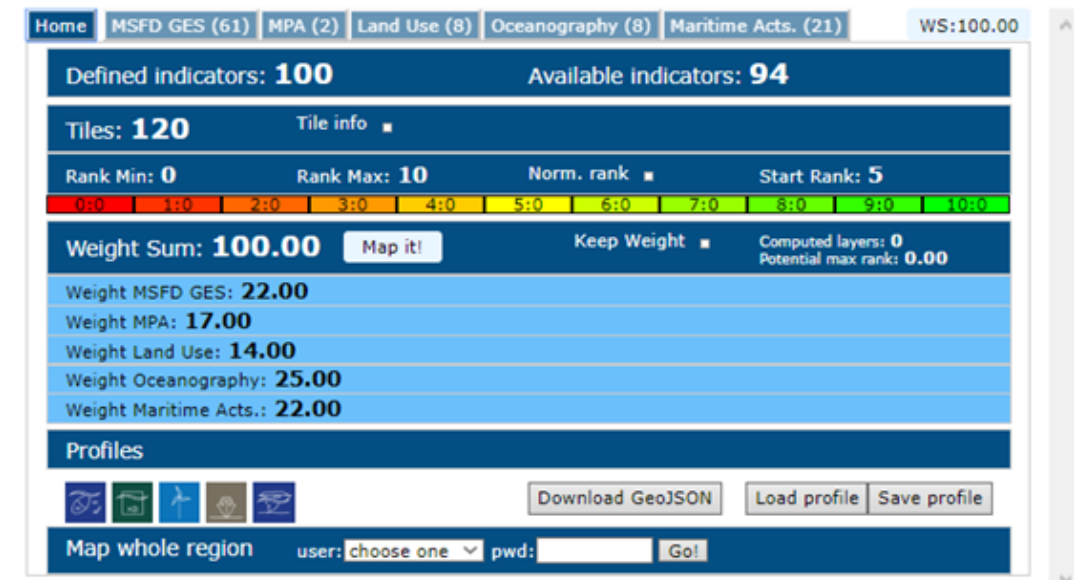

Figure 2 - INDIMAR web application and defined weights per each cluster

The DSS INDIMAR was used for calculating the location suitability for the studied maritime activities. The location suitability (R) is classified from 0 to 10, where R= 0 means absolutely unsuitable location, and R=10 most appropriate site.

Suitability (R) is calculated for each cell, as a sum of parameters weights and sum of parameters contributions:

R = Σ pWi* CVi

With condition that:

$$\Sigma\ pW_i = 100$$

Each parameter values are divided into ranges (for numerical values e.g wind speed <7 m/s, 7-8.5 m/s , >8.5 m/s; Figure 2) or dived into categories (e.g. types of Natura 2000: Birds Directive; Habitat Directive; Birds and Habitats directives; Figure 2). Parameter ranges and categories are classified regarding their contribution (CV) to the OWE suitability and have been colour coded in DSS INDIMAR (Figure 3):

1.   Positive contribution CV = 1 (green)

2.   Neutral contribution CV = 0 (yellow)

3.   Negative contribution CV = - 1 (orange)

4.   Excluding value R = 0 (red)

Parameter weighs and contributions are directly included in DSS INDIMAR and can be easily modified using web application, adjusting parameters for other sea region or other maritime sector.

Figure 3 – Use case of parameter values divided into ranges (for numerical values e.g wind speed <7 m/s, 7-8.5 m/s , >8.5 m/s) and case of parameter values divided into categories (e.g. classification of Natura 2000 network)

DSS   INDIMAR   is   publicly   available   at   ULPGC   geoportal: http://www.geoportal.ulpgc.es/indimar/ Intellectual property rights are protected with Safe Creative license.
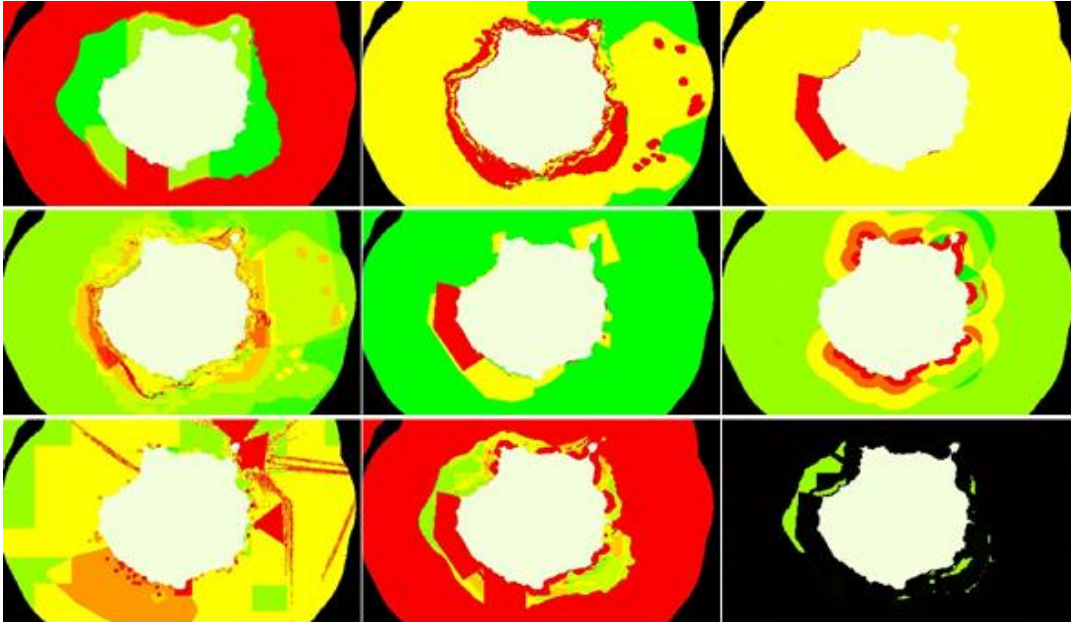
Figure *4 – Offshore Wind Energy suitability analyses delivered by Decision Support System INDIMAR tool around Gran Canaria Island. Detail: Wind&depth potential; Habitat restriction and suitability; Marine birds restriction; Suitability based on environmental (GES) sensibility; Marine Protected Areas sensibility analysis; Land Sea Interaction analysis; Current maritime uses conflict/suitability analysis; Integrated analysis; Selected areas for OWE*

3.4 Defining cluster/parameters significance (weights)

To finalize analysis, it was necessary to define weights for each parameter and to introduce them in the INDIMAR DSS tool. Defining the parameters' weights/significance was one of the most complicated tasks within this methodology development. Analytical Hierarchy Process was selected as the most appropriate methodological approach to facilitate definition of the weights, by applying pairwise analysis for all the parameters and clusters. Study on selecting and benchmarking statistical methods applicable for our use case, zoning methodology could be found at:

https://drive.google.com/drive/folders/1Ft9hDd8ZPs5KAFD16GB3-Qo3nUxdD_II

AHP method consists of the pairwise comparison of criteria in a matrix and a subsequent comparison of alternatives per criteria in order to output a rank of alternatives. As a result, this method demands the confrontation of the alternatives per criteria, in order to define a final grading.

Example of the excel sheet, used for the pairwise comparison consultations, including parameters relevant for the offshore wind energy could be found at:

https://drive.google.com/file/d/1rFjgfb3pBmG5_hmiUEKsy81-29_Sjxk1/view?usp=sharing

The consultation of the weight for each cluster / parameter was done at three different levels: A) applied to the project's partners, since they developed research over the Macaronesia area and, as a result, they also hold the structured framework of PLASMAR project within their research,. B) Within each partner's institution, external experts were identified for each sector. And C) Interested stakeholders were consulted during ad-hoc meetings related with the EASME project MarSP, which was mainly focusing on Marine Spatial Planning processes at the Macaronesian archipelagos.

The consultation took when possible, grades were given per sector, and per archipelago separately, even though experts did not act as one single individual the aggregation of the individual judgments (AIJ) was adopted. In this manner, in the aggregation where the reciprocal property was assumed, the geometric mean was used instead of the arithmetic mean.

4   Added value

Collected data and all available spatial information were included in the INDIMAR DSS tool. The relationship within parameters and each maritime sector, such as the case of aquaculture, offshore wind energy, maritime transport, fisheries and sand extraction is defined in that web-based application. In a later step, the significance (weights) per each parameter is defined and included in the DSS INDIMAR tool.

The outputs of the analysis with the INDIMAR DSS tool provides suitability location maps for introduction or expansion of the analyzed sectors. Please see examples of offshore wind energy introduction in the Canary Islands, Madeira and Azores (Figure 5, Figure 6 and Figure 7). This suitability location maps defines the optimal pilot zoning for each marine / maritime sector included in the analysis, which may be altered later with the introduction of new inputs in the INDIMAR DSS tool, such as additional governmental rules or economic drivers.
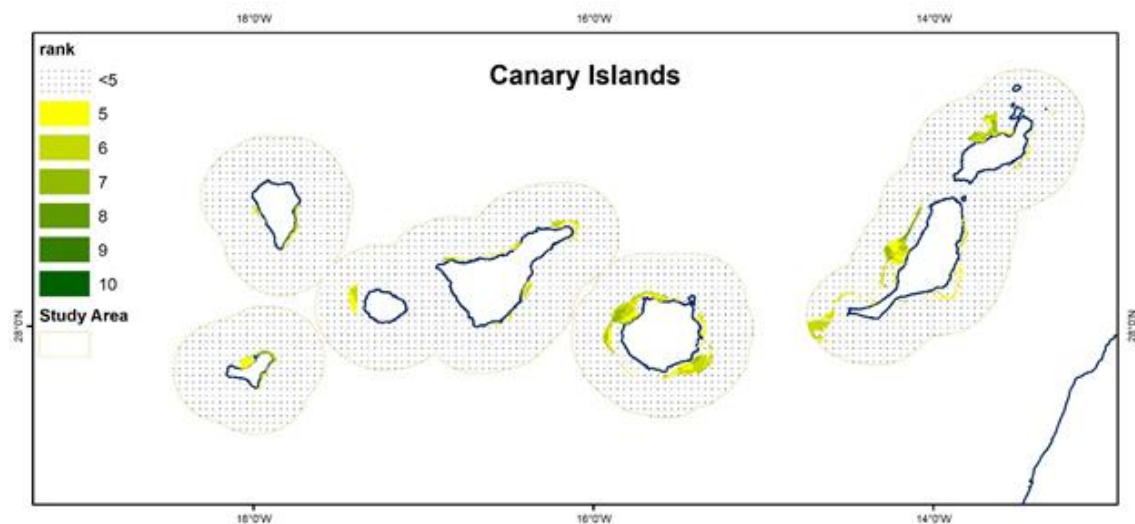

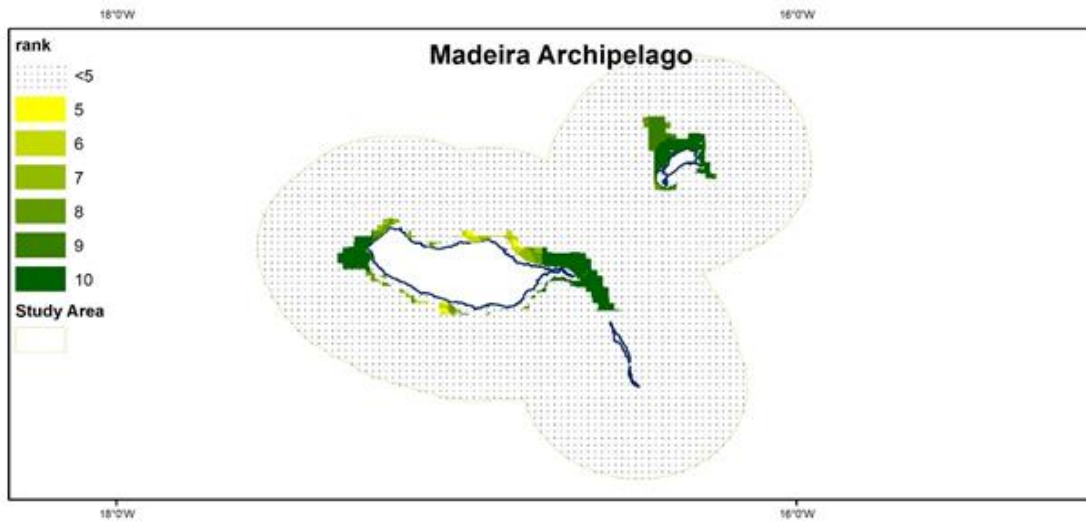*Figure* 5 - Offshore Wind Energy suitability analysis for the Canary Islands.

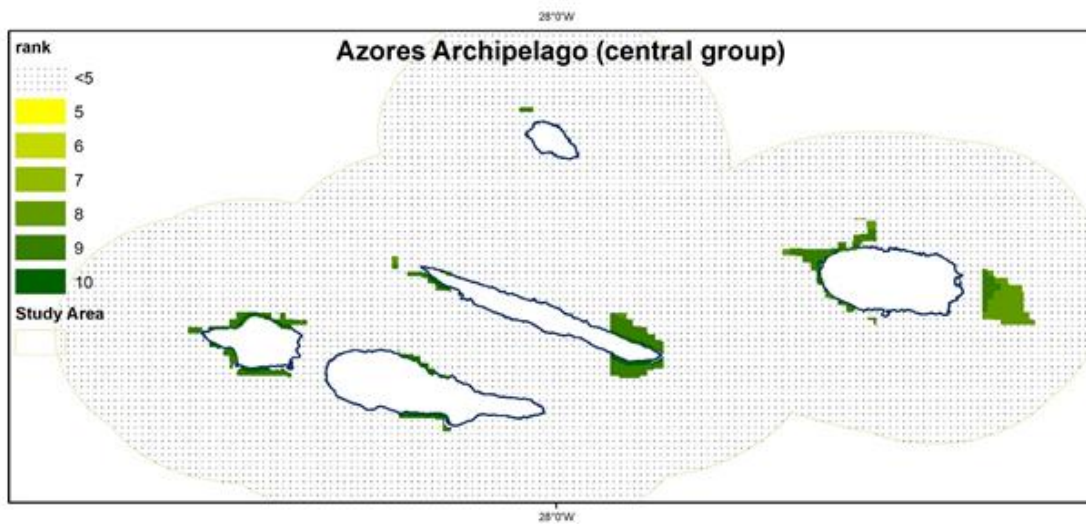*Figure 6 - Offshore Wind Energy suitability analysis for Madeira Archipelago.*

Figure 7 - Offshore Wind Energy suitability analysis for central group of Azores islands.

5 Annex

Supplementary information are available in the following PLASMAR project reports:

- Abramic, A; Norton, C; Haroun, R. 2018. Finding the Balance of Blue Growth Sustainable Development within Ecosystem Approach (2.1.1 c&d). Analysis of the Offshore Wind Industry in Macaronesia under MSFD. University of Las Palmas de Gran Canaria; Dublin Institute of Technology. Report prepared as part of the PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). IU-ECOAQUA, Univ. Las Palmas de Gran Canaria. 59 pp

- Couce-Montero, L; Bilbao-Sieyro, A; Pérez-González, Y; Abramic, A; CastroHernández, JJ. 2019. Analysis of the professional fishing sector in Macaronesia under MSFD. Finding the Balance of Blue Growth Sustainable Development within Ecosystem Approach (Act. 2.1.1 c&d). GMR Canarias, S.A.U. & ECOAQUA-ULPGC. Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 120 pp

- *Fernández-Palacios, Y. 1, L. Png-Gonzalez2, N. Nogueira2, S. Kaushik1, R. Haroun1 & A.Abramic1. 2018. Task report: Workshop and meetings on "Good Environmental Status & Aquaculture". 19-23 March 2018, IU-ECOAQUA, Canary Is. (Spain). Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 14p. Available at:* http://www.plasmar.eu/documentos/

- Png-Gonzalez L., Andrade C., Abramic A., Nogueira N. 2019. Analysis of the aquaculture industry in Macaronesia under MSFD. Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 53 pp. Available at: http://www.plasmar.eu/documentos/

- *Shinoda, Deborah; Calado, Helena; Vergílio, Marta. 2019. 'Identification of Areas for Blue Growth: The development and application of a multicriteria analysis to support maritime spatial zoning'. University of Azores. Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 27 pp.*

- *Shinoda, Deborah; Calado, Helena; Vergílio, Marta; Kramel, Diogo; Caña Varona, Mario. 2018. Identification of Areas for Blue Growth: Detailed MCDA Draft Methodology. University of Azores. Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 25 pp.*

- *Shinoda, Deborah; Kramel, Diogo; Calado, Helena; Vergílio, Marta; Caña Varona, Mario. 2018. MCDA Methodological Alternatives report. University of Azores. Report prepared as part of PLASMAR Project (co-financed by ERDF as part of POMAC 2014-2020). 22 pp.*