MOSES

Maritime, Ocean Sector and Ecosystem Sustainability: Fostering Blue Growth in Atlantic Industries

Data base that identifies pressures by sector by marine ecosystem affected

ACTION NUMBER: 2

Work Package: WP5
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Interreg Atlantic Area
European Regional Development Fund
EUROPEAN UNION

DESCRIPTION OF WORK PACKAGE 5

The Blue Growth Agenda has placed the importance of marine resources for economic development in its forefront Most of the reports on Blue Growth have focused on the value added creation (current and potential) of the maritime sectors whose growth depends on healthy marine ecosystems. Following the implementation of the Marine Strategy Framework Directive (MSFD) (ref), the European Union (EU) member states started to assess the environmental status of their marine waters.

The goal of the MSFD is to achieve Good Environmental Status (GES) of EU marine waters. The MSFD provides descriptors, associated criteria and indicators that include biological, physic-chemical and pressure indicators to interpret what GES means. However, and as highlighted by the European Environment Agency, following the initial assessments under the MSFD, more effort is needed to improve the understanding of the linkages between marine economic activities and their pressures and impacts on marine environment.

Following this sequence, the aim of this work package is to define a set of activity specific pressure indicators and, where appropriate, identify cross-sectoral pressures that, in addition to the state indicators, can be used to implement a sustainable management regime. The work of developing a common set of pressure indicators, that can be used in the whole Atlantic Arc, requires coherence, coordination and cooperation: This is the correct way to provide an inter-regional comparative analysis of the environmental impact of the blue economy across the Atlantic Arc.

Action 2: Identify and collect the missing pressure data

Action description: This action will cross-check the output from action 1 and data available from WP4, data available from Member States assessments under the MSFD and mapping exercises under the EU MAES project, in order to establish a dataset that contributes to assessing the maritime sectors' pressures on the marine environment. The analysis provides support for the continued implementation of the MSFD and the achievement of blue growth across marine sectors by identifying the pressure-impact pathways.

Outputs description: A set of data that contributes to assessing the maritime sectors' pressures on the marine environment. The database will provide an overview of main pressures on different marine ecosystems types.

1. INTRODUCTION

An important blue economy's context is currently presented across the Atlantic Area (AA) coastal countries with both traditional but also emerging sectors providing high revenues and high number of quality jobs. And therefore, assuring the blue growth sustainability is the way of maintaining those good business and social indicators over the medium and long term. However, more research effort is needed to operationalize the way in which the different sectors (from fishing to maritime transport or tourism sectors) can define and assess their contribution not only to the socioeconomic growth of the AA, but also, to the sustainability of this area. European policies as the MSFD stablished a common framework, to be later developed by Member States (MS), under which the MS should be able to assess the use of the seas by the economic activities. Therefore, it is necessary to extend the concept among policy makers and sea sectors-related stakeholders to ensure that only sustainable undertakings will be developed in the AA. This is not an easy task and it has to be coordinated at AA level and even at supra AA level given that the economic activities happen across national borders and even, across AA borders. Therefore, the blue growth sustainability concept and assessment represents a common challenge. When assessing the blue growth sustainability, it is important to distinguish between those sectors which MS national activities happen locally, inside the AA, from those that take place across AA borders. Thus, the Blue growth assessment provided by these MS national activities, measured in terms of revenues and jobs, does not necessarily produces a local impact on the AA marine environment. Blue growth sustainability implies to consider the blue growth assessment as a key driver but it is also required to consider the size and scale of the use of the seas needed to produce that blue growth especially for fishing or maritime transport activities that move across borders.

This research aims to establish a standard index to identify the sustainability of the blue growth sectors in the AA that will contribute to create new knowledge for sustainable oceans policy. Under this context, the objective of the WP5 is to define that index, based on a set of indicators, to assess how the economic growth of marine activities is converted into an impact - pressures on marine ecosystem services (ES). Therefore, the index represents a link between the economic activities in a region and their pressures on the marine environment through the ES. This may be a novel guidance for stakeholders as it improves our knowledge on the different impacts of the activities that contribute to the blue economy assessment. The quantification of this index will allow us to conduct an inter-regional comparative analysis for the environmental pressure carried out by the blue economy across the Atlantic Arc.

2. METHODOLOGY

The methodology has been explained in detailed as part of the Deliverable from Action 1 of this WP5. Here, we present a summary.

The terminology to be used is related to the A(ctivities)-P(ressure) link of the causal chain of D(A)PSI(W)R(M) framework described in Elliot et al. (2017). We depart from the characterization of the maritime economy for the European Atlantic Periphery developed by the Marine Atlantic Regions Network (MARNET) project (EC, 2011). In MARNET project, a wide range of business indicators, physical indicators (or proxies) and population and social data were collected for each industry by NACE[1] code. These has been also updated by the MOSES project. These “activity” indicators correspond to subsets or aggregate maritime “sectors”. Each of the maritime sectors (e.g., commercial fishing) include different types of activities (e.g., trawling, long-lines, etc.) that may imply different pressures for each of the marine ES considered.

[1] Nomenclature Generale des Activites Economiques dans les Communautes Europeennes

In order to have a more accurate link between the indicators of (A)ctivities and the associated (P)ressures, here we will use "sector" indicators but adding other variables that allow us to take into account the presence of prevention, mitigation or compensation between each sector's activities and the pressures over each of the marine ES.

As it is mentioned previously, blue growth sustainability implies to consider the blue growth assessment but also, the size and scale of the use of the seas needed to produce that blue growth assessment. We define and develop the index by building a sector-pressure-ecological component linkage. This component linkage follows the impact chain defined by Knights et al. 2013[2]. The index introduces some pressure assessment criteria and categories considering the ecological component in two ways. First, we introduce the sensibility of the benthic habitats to the maritime economic activities. Second, we consider the impact of these activities on the so-called marine ecosystem goods and services. Regarding the marine ES, we follow the Millennium Ecosystem Assessment (MEA)[3] where the benefits people obtain from ecosystems (ES, ES) are classified into four groups: Provisioning, Regulating, Cultural and Supporting services. In this work we focus on specific food provisioning services, cultural services related to the tourism and recreational services and, other intermediate ecosystems services (climate regulation[4]). To this respect, it is key to emphasize the index will consider a local impact on ES but also, a global impact on regulating services, through CO2 emissions (see Figure 2).

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2 Knights, A.M., Piet, G., Jongbloed, R. and Robinson, L.A. 2013. An exposure-effect risk assessment methodology to evaluate the performance of management scenarios: Case study examples fromEurope's regional seas. Deliverable 9, EC FP7 project (244273) "Options for Delivering 16 Ecosystem based Marine Management". University of Liverpool. ISBN: 978-0-906370-84-1: 43 pp.

3 Millenniumassessment.org

4 Carbon fluxes regulation and the carbon footprint from economic activities.

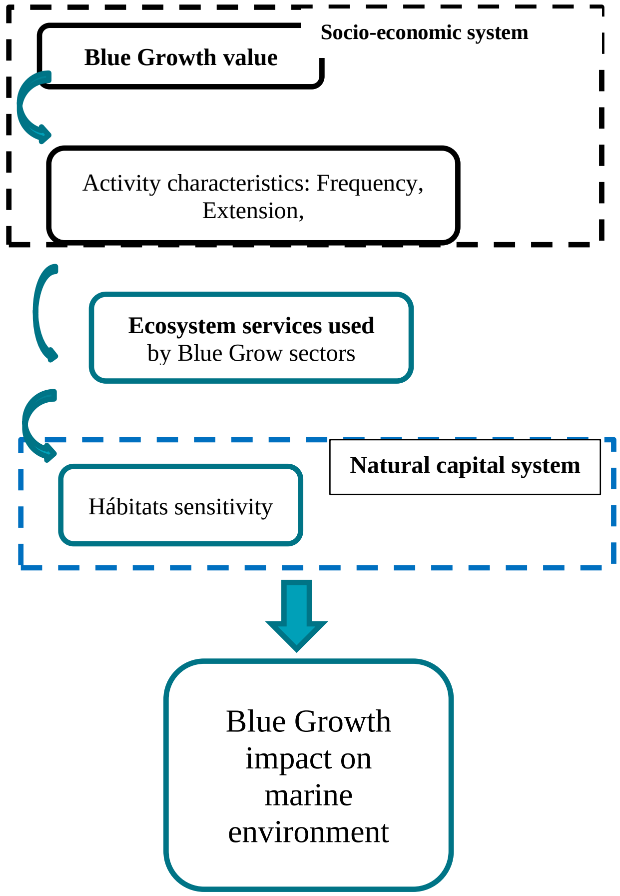

Figure 1. The Blue Growth Economics: a key driver impacting marine environment through the ES.

Before moving into the index it is important to remark that the quantification of the pressure generated by economic activities in any region is more difficult for those activities which belong to one particular AA, but that have their activity out of the Atlantic (i.e. fishing sector and maritime transport sector). In a similar way, an important part of the impact in the AA that comes from the non-regional economic activities is therefore missing.

Only for those specific sectors, an additional index is estimated as complementary to the previous one. It is an index to assess at which degree the economic activity developed in the region by any regional or non-regional activity (from outside the AA) is transferred into regional pressures on the marine ES. This is the so-called territorial blue growth pressure index (Figure 2).

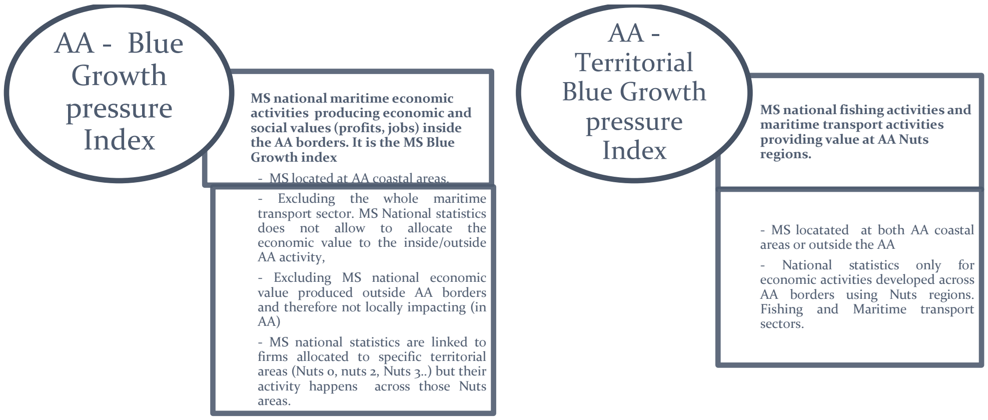

Figure 2. Atlantic Area Blue Growth Pressure Index (BG Pressure Index) and AA Territorial Blue Growth Pressure Index (TBG Pressure Index)

For simplicity purposes, we define the general formulation for assessing the index pressure, being identified as $P_{k,r}$. Depending on the statistics and sectors considered we can estimate AA BG Pressure Index or AA TBG Pressure Index.

The index we have defined, $P_{k,r}$, measures the pressure generated by economic activity at region r on the ecosystem service k and it is defined as follows:

$$P_{k,r} = \sum_{i=1}^{n} \sum_{k=1}^{m} w_{ik} \, \mu_{ik} \, A_{ik}$$

where,

- w_{ik} is a weighted factor that allows the linear aggregation: $\sum_{i=1}^{n} \sum_{k=1}^{m} w_{ik} = 1$. It can also be a social factor representing stakeholders' perceptions. We can analyze and compare the results obtained when w_{ik} is determined by different stakeholders (researchers, maritime sectors related stakeholders or policy makers).

- μ_{ik} is the weight of the pressure exerted by the economic activity i on the ecosystem service k. Based on a literature review, we assign a weight to the pressure that each of the blue economic activities (i =1, … , n) has on each of the ecosystem service ($k = 1, \dots, m$). Following Halpern et al. (2008)[5], we use a vector of weights (-1, 0, 1) to translate (A)ctivities to (P)ressures on ES. The value of the weight is -1, 0 or 1 if the activity relieves pressure, does not affect, or adds pressure on the ES, respectively.

- A_{ik} is the economic indicator associated (directly or indirectly) to activity i (of sector j) on ecosystem service k adjusted by the size and scale of the impact on the marine environment. This size and scale are measured through a set of variables (see Deliverable from Action 1. Wp5 for a detailed explanation): %Area, economic indicators, spatial extent and finally, the frequency. We use the following equation to compute A_{ik}

$$A_{ik} = a_{ik}\,(\%\,area)\ \ (1 + \%\,spatial\ extent)\ \ (1 + \%frequency)$$

where a_{ik} is an economic indicator for activity i affecting ecosystem service k.

As long as μ_{ik} can be positive or negative, we will compute $P_{k,r}$ separately for the positive and the negative values to avoid compensations among pressures.

The weighted factor, w_{ik}, can be also a social factor representing stakeholders' perceptions. We can analyze and compare the results when w_{ik} is determined by different stakeholders: researchers, maritime sectors related stakeholders or policy makers. Besides, w_{ik} can be modified by multiplying it by the inverse of the standard deviation of each of the components in $P_{k,r}$. The sum of all the weighted factors multiplied by the inverse of their standard deviation should be equal to 1 and this will minimize the influence over the

5 Halpern, B. S. et al. (2008). A global map of human impact on marine ecosystems. Science 319, 948-952.

index of those individual components with a high degree of volatility (Mondejar and Vargas-Vargas, 2008)[6].

We can also compute the aggregated pressure of the local economy on the marine environment by adding the effects on all the ES (ES):

$$P_r = \sum_{K=1}^{m} P_{k,r}$$

Finally, we conduct a sensibility analysis to check the robustness of the index to the input data.

3. DATA REQUIREMENTS

Data requirements needed to build the index depend on the type of sectors and economic activities included as part of the index. Here we consider 19 economic activities and their local and global impacts on four ES (k. services): provisioning (1), regulating (2), supporting (3) and cultural (4) (Table 1).

[Insert Table 1]

The local and global impact pressure index is built based on a set of variables described in the previous section and here we describe data requirements. This index will be run using R software and it requires the preparation of a working environment to storage the data. This environment is composed by two data sources, the **europe.aik.csv and VAR.INDEX_Europe.xlsx files,** that are prepared to include the data required and collected across coastal areas in the AA. In the excel file *VAR.INDEX_Europe*, there are

6 Mondéjar, J., and Vargas-Vargas,M. (2008). Synthetic indicators: a revision of aggregration methods. Economía, Sociedad y Territorio, vol. VIII, núm. 27, 565-585.

different sheets, each of them containing information on the variables needed to estimate the index. In the CSV file *europe.aik*, it has been storage the raw values collected in WP4, which will be adapted to be used as a_{ik}values in the index. These two files are provided, to be attached to this document, as part of this Deliverable.

The following subsections explain the different variables for which data are storage in the previous two excel files. Table 2 summarise the working environment to storage the data.

3.1 Impact weights (w_{ik})

The impact weights of human activities on ES represent the sign of the pressure exerted by each activity. The value of this parameter is obtained from previous literature and considered to be equal for all the areas in the AA. Therefore, differences can be observed through the economic activities but not across the AA. Table 3 shows the adopted values of *mu.weight* variable for each activity classified by NACE code. Note that, this variable can only take three potential discrete values: (i) -1, if pressure has a positive effect on the ES; (ii) 0, if pressure does not have any significant effect on the ES, and, (iii) 1 if the pressure has a negative effect on the ES. These pressures might imply both a local impact and a global impact. The global impact is measured through the regulating ES.

The data showed in

Table 3 is stored in ***VAR.INDEX_Europe.xlsx.***

[Insert

Table 3]

3.2 Economic indicators, a_{ik}

The economic indicators represent the selected variables able to characterize the economic activity volume in terms of business indicators or proxies. These business indicators used to provide assessment of the blue growth are also a key component when assessing if the activities impacts are proportional or more than proportional to that growth.

These variables will be specifically selected for each economic activity and each ecosystem service. However, the analysis mainly focuses on two key aspects of blue economy: output (in monetary terms, revenues, added value, or profits) and employment. Take for instance, the case of the NACE 3.11 fishing activity. It is used the turnover, revenues. This is the variable through which the impact of fishing activity on provisioning, regulating, and supporting ES is assessed. The turnover itself does not represent the full impact but, it can be identified if the turnover has a positive/no impact or even a negative impact depending on the different ES. The number of people employed is usually used to assess the impact of that activity on the cultural ES.

The data requirement to assess these variables is based on a data collection framework developed by WP4, based on previous MARNET project, for the economic activities across the AA.

Notice that, there are two types of pressure impact: a local pressure and a global impact.

The local impact represents the pressure that the maritime activities are exerted on marine environment when a positive or negative impact (mu.weight different from zero) is observed either on provisioning, regulating, supporting or cultural ESs. However, all economic activities are associated in a higher or lower extent to a global impact on regulating ES. For this global impact, a carbon footprint variable is used. Table 4 and Table 5 show the list of economic indicators and proxies' description and, its use through NACE economic activities and ESs. The data collected is stored in **VAR.INDEX_Europe.xlsx and, europe.aik.csv.**

[Insert Table 4 and Table 5]

3.3 % Area

%Area represents the percentage of the economic value (measured with the business indicators) produced within the AA studied area. Consider, for example, the fishing sector for which the gross economic value includes the total fishing value related to the vessels with their base port in an area, even if part of their activity and related impacts are produced outside this area.

National accounts produce the estimation of the gross economic value for each sector/country including all the value produced by that sector although not usually distinguishing between production areas. Thus, the %Area should be estimated (although it is difficult). Alternatively, it is considered that all the economic volume from the sectors is being produced within the AA. Only for the case of Spain some estimations are done based on expert knowledge. This variable data is stored in **VAR.INDEX_Europe.xlsx.**

3.4 *Spatial extent*

The Spatial extent is used to take into account that the economic activity overlaps with different ecological components of the marine environment. The higher the spatial extent, the higher the impact linked to the economic growth. This indicator is composed by two variables: (i) extension used by the activity to generate economic rents, expressed in Km2, and (ii) habitat sensitivity to the economic activities. Following, we describe the step by step process to build the Spatial extent (see in Table 6 data collected).

Step 1. Benthic habitats in the studied EU Atlantic marine areas are identified and mapped (sourced by EDMONET). Those benthic habitats provide a wide range of ecosystem goods and services from which some economic activities depend.

Step 2. Sensitivity of 62 habitats from the European North-eastern Atlantic Ocean is incorporated following the analysis and mapping by Alkiza et al, 2016[7]. These authors show that fishing activities, especially by benthic trawls, coastal development, and mining, are the main threats to European seabed biotopes. Meanwhile, these same activities along with dredging, sediment disposal and hydrocarbon exploration are the ones affecting a huge number of habitats.

Step 3. We overlap the Atlantic marine areas with each territorial region (NUTS2)[8]. Specifically, the NUTS2 2016 (terrestrial) regions were projected in the European grid, based on ETRS89 Lambert Azimuthal Equal-Area projection coordinate system (EPSG:3035). This allows measurement in metres, rather than degrees and it is the official European projection system widely used for Pan-European analysis according to the EEA[9]. The median lines between NUTS2 regions within each Member State EEZ were generated following a similar methodology with Marineregions.org[10]. More specifically, the median lines were calculated using Thiessen polygons (also known as Voronoi polygons) following this procedure:

(i) a dense network of points was created along the coast using as input the polygon layer NUTS2 terrestrial boundaries in QGIS 3.2.0 (function Extract vertices). Each point was automatically linked to NUTS2 based on the attribute NUTS2_ID.

7 Alkiza, M., Galparsolo, I., Uyarra, M., Muxica, I., and Borja, A.(2016). Mapeo de la sensibilidad ecológica de los hábitats bentónicos frente a las actividades humanas en el noreste Atlántico. Revista de InvestigaciónMarina, AZTI, 23(2): 9-2.

8 NUTS2 terrestrial boundaries. NUTS_RG_01M_2016_3035_LEVL_2 - https://ec.europa.eu/eurostat/web/gisco/geodata/reference-data/administrative-units-statistical-units/nuts.

9 EEA (2017). EEA reference grids. Available at: https://www.eea.europa.eu/data-and-maps/data/eea-reference-grids INSPIRE (2017). D2.8.I.2 Data Specification on Geographical Grid Systems – Technical Guidelines. Available at: https://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_GG_v3.1.pdf

10 Marineregions.org (2019). Methodology for the creation of the Maritime Boundaries. Available at: https://www.marineregions.org/eezmethodology.php

(ii) The point layer produced was used as input to draw the median lines among the NUTS2 regions. Median lines connect points which are located at equal distance from each NUTS2 region. To do so, Thiessen polygons were created in QGIS 3.2.0 (function Voronoi polygons). Again, each Thiessen polygon was automatically linked to NUTS2. Note that this process creates thousands of Thiessen polygons within each EEZ.

Step 4. Finally, once the areas are defined, and considering the sensitivity criteria from Alkiza et al., 2016 the spatial extent value is produced (Table 6). This variable data is stored in **VAR.INDEX_Europe.xlsx.**

[Insert Table 6]

3.5 Frequency

Frequency represents how often a pressure type and ecological characteristic interaction occurs measured in months per year and standardized to 100%. Previous literature (Knights et al. 2013, Knights et. al. 2015[11]) is considered when defining this variable but updated to include the seasonal characteristic of some economic activities, which are usually carried out across the whole year but with a higher intensity in some specific months.

Table 7 shows the values we consider: Persistent -100%; Common – 70%, Occasional- 40% and, Rare – 20%. Statistical sources are used to estimate it when available. In other cases, the data is completed using empirical knowledge.

4. DISCUSSION

[11] Knights, A. M., Piet, G. J., Jongbloed, R. H., Tamis, J. E., White, L., Akoglu, E., Boicenco, L., Churilova, T., Kryvenko, O., Fleming-Lehtinen, V., LeppanenJuha-Markku, Galil, B. S., Goodsir, F., Goren, M., Margonski, P., Moncheva, S., Oguz, T., Papadopoulou, K.N., Seta¨la¨, O., Smith, C. J., Stefanova, K., Timofte, F., and Robinson, L. A. 2015. An exposure-effect approach for evaluating ecosystemwide risks from human activities. – ICES Journal ofMarine Science, 72: 1105–1115.

The overall importance of maritime economic activities has been largely measured in economic and social terms through variables such as revenues, gross value added, profits and jobs. These mesures, however, do not consider the impacts of that economic activities on the marine ES. The main objective of this work is to develop and measure an index to assess the maritime economic sector's pressures on the marine environment through the marine ES

We focus in the Atlantic Area (AA) where official statistics for each maritime sector is usually available by EU Member State at NUTS0 level, but the difficulties arise when trying to get those values at NUTS 3 levels. Thus, increasing the knowledge on subregional coastal areas is a main challenge for these areas.

A major challenge is also to assess the blue economy's impact at the local, regional, and global levels. This research proposes an index based on a set of indicators to adjust the previous traditional variables to better identify the scale and size of the activity and therefore, the use of the seas. However, it is very difficult to get reliable data across Member States. For instance, it is quite difficult to determine which part of the production of some maritime sectors is generated inside/outside the Atlantic Area.

Estimating the Blue Growth, its size, scale and therefore, the impact of marine economic activities on ES has yet to be better developed. This research represents a good attempt towards this objective. To this aim, a complete database is presented with homogenous and comparable data for the whole Atlantic Area.

Appendix – Tables

Table 1. *Economic activities classified by NACE*

Section	Division	NACE	Description
A	*03*	*03,11*	*Marine fishing*
A	*03*	*03,21*	*Marine aquaculture*
B	*08*	*08,12*	*Operation of gravel and sand pits; mining of clays and kaolin*
B	*09*	*09,90*	*Support activities for other mining and quarrying*
C	*30*	*30,11*	*Building of ships and floating structures*
C	*30*	*30,12*	*Building of pleasure and sporting boats*
D	*35*	*35,11*	*Production of electricity*
H	*50*	*50,10*	*Sea and coastal passenger water transport*
H	*50*	*50,20*	*Sea and coastal freight water transport*
H	*50*	*50,30*	*Inland passenger water transport*
H	*50*	*50,40*	*Inland freight water transport*
I	*55*	*55,10*	*Hotels and similar accommodation*
I	*55*	*55,20*	*Holiday and other short-stay accommodation*
I	*55*	*55,30*	*Camping grounds, recreational vehicle parks and trailer parks*
I	*56*	*56,10*	*Restaurants and mobile food service activities*
I	*56*	*56,30*	*Beverage serving activities*
N	*77*	*77,34*	*Renting and leasing of water transport equipment*
R	*93*	*93,11*	*Operation of sports facilities*
R	*93*	*93,29*	*Other amusement and recreation activities*

__Table 2.__ working environment to storage the data that later will be used by RStudio

	Activity	Variable	Description	Type (quantitave or qualitative)	Values	ES (K.service)	NACE NUTS 0						NACE NUTS 2					
							Sp	**Pt**	**Fr**	**UK**	**IR**	**AA**	**Sp**	**Pt**	**Fr**	**UK**	**IR**	**AA**
	3.11;3.21 8.12; 9.90; 30.11;30.12; 35.11;50.10; 50.20;55.10; 55.20;55.30; 56.10;56.30; 77.34;93.11; 93.29	μ.weight	μ values - represents the sign of the pressure exerted by the activity	**Qualitative**	**-1,0,1**	**1, 2, 3, 4**						**x**						**x**
		w_{ik}	Weighting factor for linear aggregation	Quantitative	$\sum_{i=1}^{n}\sum_{k=1}^{4} w_{ik} = 1$	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	3.11; 3.21 8.12; 9.90; 30.11;30.12; 35.11;50.10; 50.20;55.10; 55.20;55.30; 56.10;56.30; 77.34;93.11; 93.29	$(\% \, area)$	% of economic indicator value within AA	Quantitative		1	x	x	x	x	x							
		Extension Km2		Qualitative	Widespread, Local, Site	-	x	x	x	x	x		x	x	x	x	x	
		Habitat sensitivity		Qualitative	High, Medium, Low	-	x	x	x	x	x		x	x	x	x	x	
		% spatial extent			[40%-100%]													
		% frequency	How often the economic activity takes place yearly	Qualitative	Persistent, Common, Occasional, Rare	-	x	x	x	x	x		x	x	x	x	x	
		CO2	Carbon footprint	Quantitative	GHG emissions (TMe)	-	x	x	x	x	x		x	x	x	x	x	
Economic Indicator, Aik	3.11	a_{ik}	Economic indicator	Quantitative	V12110, V16110,	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	3.21	a_{ik}	Economic indicator	Quantitative	V12110, V16110	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	8.12	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P9	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	9.90	a_{ik}	Economic indicator	Quantitative	V12110, V16110, CO2	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	3.21	a_{ik}	Economic indicator	Quantitative	V12110, V16110	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	30.11	a_{ik}	Economic indicator	Quantitative	V12110, V16110	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	30.12	a_{ik}	Economic indicator	Quantitative	V12110, V16110	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	35.11	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P13	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	50.10	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P18	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	50.20	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P19	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	55.10;55.20; 55.30	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P20, CO2	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	56.10;56.30; 77.34;	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P22, CO2	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	93.11	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P23, CO2	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	
	93.29	a_{ik}	Economic indicator	Quantitative	V12110, V16110, P24, CO2	**1, 2, 3, 4**	x	x	x	x	x		x	x	x	x	x	

Within the cells, Y stands for data found and collected, N for data not found and 0 for no activity NF: Not considered in the theoretical framework.
YEARS: 2013,2014, 2015

Table 3. *Mu weight for all economic activities classified by NACE*

j.sector	NACE	i.number	k.service	mu.weight	reference	comments
A	03,11	1	1	1		
A	03,11	1	2	1		Ecological footprint is considered
A	03,11	1	3	1	IFRO 2015	*Fishing stresses the supporting (e.g. the food web, biodiversity) and the regulating (e.g. Impairs the fish stocks ability to recovery from diseases) services. The effects on the ecosystem from fishing differ by gear-type. Fishing with bottom contacting gears (trawls and dredges) affects production in the habitats while pelagic fishing gears affect marine mammals and sea birds*
A	03,11	1	4	-1	IFRO 2015	*It would be possible to distinguish commercial large-scale fishing from small-scale commercial and recreational fishing because their contribution to the cultural services differs. However, this research considers a positive effect which relieves pressure.*
A	03,21	2	1	0		
A	03,21	2	2	1	Naylor et al 2000	*Effluent discharge: untreated wastewater laden with uneaten feed and fish faeces may contribute to nutrient pollution near coastal ponds and cages*
A	03,21	2	3	1	Naylor et al 2000	*Habitat modification: Hundreds of thousands of hectares of mangroves and coastal wetlands have been transformed into milkfish and shrimp ponds. This transformation results in loss of essential ES generated by mangroves, including the provision of nursery habitat, coastal protection, flood control, sediment trapping and water treatment*
A	03,21	2	4	1	Deniz et al 2001	*Recreational interests arise from yachts and pleasure boats, divers, snorkellers, windsurfers and swimmers and sports fishermen. All of these activities require good water quality, windsurfers and swimmers and sports fishermen. and large areas of uncluttered water surface. The effects of aquaculture can be deleterious to these by increasing turbidity through over-feeding and poor waste management. Aquaculture can conflict with yachting by causing navigational hazards.*
B	08,12	3	1	0	DEVOTES D.1.2	*Selective extraction of non-living resources --> aggregate extraction/removal of surface substrata. It will be 1 if not only focusing on food provision*
B	08,12	3	2	1		Ecological footprint
B	08,12	3	3	1	DEVOTES D.1.2	*Selective extraction of non-living resources --> aggregate extraction/removal of surface substrata*
B	08,12	3	4	0		
B	09,90	4	1	0		Similar to 08.12
B	09,90	4	2	1		Similar to 08.12
B	09,90	4	3	1	DEVOTES D.1.2	*Selective extraction of non-living resources --> aggregate extraction/removal of surface substrata*
B	09,90	4	4	0		Similar to 08.12
C	30,11	5	1	0		
C	30,11	5	2	1		Ecological footprint // and introduction of polluting substances
C	30,11	5	3	1	Gomoiu 2001	*Ships building --> Coastal zone industrialization and urbanization --> changes of the coastline --> loss/changes of the habitats and landscapes --> loss of biodiversity*
C	30,11	5	4	1	Gomoiu 2001	*Ships building --> Coastal zone industrialization and urbanization --> changes of the coastline --> loss/changes of the habitats and landscapes // if linked to a more traditional ship building industry, it could be a positive efect (Albaola)*
C	30,12	6	1	0		
C	30,12	6	2	1		Ecological footprint and introduction of polluting substances
C	30,12	6	3	1	Gomoiu 2001	*Ships building --> Coastal zone industrialization and urbanization --> changes of the coastline --> loss/changes of the habitats and landscapes --> loss of biodiversity*
C	30,12	6	4	1	Gomoiu 2001	*Ships building --> Coastal zone industrialization and urbanization --> changes of the coastline --> loss/changes of the habitats and landscapes*
D	35,11	16	1	0		

j.sector	NACE	i.number	k.service	mu.weight	reference	comments
D	35,11	16	2	1		
D	35,11	16	3	1		
D	35,11	16	4	0		
H	50,10	7	1	0		
H	50,10	7	2	1	Walker et al. 2017	*Oil spills // HNS spills // oceans around the world are impacted by environmental degradation due to garbage pollution generated by ships // ship-sourced food waste can reduce water and sediment quality, damage marine biota, increae turbidity and nutrient levels*
H	50,10	7	3	1		
H	50,10	7	4	-1		
H	50,20	8	1	0		
H	50,20	8	2	1	Walker et al. 2017	*Oceans around the world are impacted by environmental degradation due to garbage pollution generated by ships. Ship-sourced food waste can reduce water and sediment quality, damage marine biota, increae turbidity and nutrient levels*
H	50,20	8	3	1		
H	50,20	8	4	0		
I	55,10	11	1	0		
I	55,10	11	2	1		*Ecological footprint*
I	55,10	11	3	0	Sunlu, 2003	*Construction of hotels, recreation and otehr facilities often leads to increased sewage pollution. Wastewater pollutes seas and lakes surrounding tourist attractions, damaging the flora and fauna. Changes in Salinity and transparency can have wide-ranging impacts on coastal environments. And sewage pollution can threaten the health of humans and animals. It might be 1 if activity is allocated close to the coast.*
I	55,10	11	4	-1		
I	55,20	12	1	0		
I	55,20	12	2	1	European Environment Agency, 2017	*Coastal and marine tourism is one of the main causes of marine litter, which in turn is a serious threat to marine habitats, species, ecosystems and tourism*
I	55,20	12	3	0		
I	55,20	12	4	-1		
I	55,30	13	1	0		
I	55,30	13	2	1	European Environment Agency, 2017	Coastal and marine tourism is one of the main causes of marine litter, which in turn is a serious threat to marine habitats, species, ecosystems and tourism
I	55,30	13	3	0		
I	55,30	13	4	-1		
I	56,10	14	1	0		
I	56,10	14	2	1		*Ecological footprint*
I	56,10	14	3	0		
I	56,10	14	4	-1		
I	56,30	15	1	0		
I	56,30	15	2	1		*Ecological footprint*
I	56,30	15	3	0		
I	56,30	15	4	-1		
N	77,34	16	1	0		
N	77,34	16	2	1		*Ecological footprint*

j.sector	NACE	i.number	k.service	mu.weight	reference	comments
N	77,34	16	3	0		
N	77,34	16	4	-1		
R	93,11	17	1	0		
R	93,11	17	2	1		*Ecological footprint*
R	93,11	17	3	1	Sunlu, 2003	*Development of marinas and breakwaters can cause changes in currents and coastlines. Overbuilding and extensive paving of shorelines can result in destruction of habitats and disruption of land-sea connections*
R	93,11	17	4	-1		
R	93,29	18	1	0		
R	93,29	18	2	1		*Ecological footprint*
R	93,29	18	3	1	Sunlu, 2003	*Development of marinas and breakwaters can cause changes in currents and coastlines. Overbuilding and extensive paving of shorelines can result in destruction of habitats and disruption of land-sea connections*
R	93,29	18	4	-1		

***Table 4**. Business indicators or proxies (physical variables)*

Business indicators/Proxies	Economic indicator (a)	Economic indicator description	Unit
	V11110	**Number of enterprises**	-
	V12110	*Turnover or gross premiums written*	*1,000 EUR*
	V16110	*Number of persons employed*	*1,000*
	P1	*Landing tonnage/Atlantic NUTS3*	*1,000 tonnes (t)*
	P9	*Overall sand and gravel production value / Atlantic dredge areas*	*million EUR*
	P13	*Installed capacity of marine renewable energy/type of technology/Atlantic NUTS2*	*MW*
	P18	*Overall passenger traffic / main Atlantic ports*	*1,000 passengers*
	P19	Overall goods throughput / main Atlantic ports	1,000 t
	P20	*Number of nights/Atlantic NUTS3*	*1,000 nights*
	P22	*Number of establishments/Atlantic NUTS3*	-
	P23	*Number of nautical sport facilities / Atlantic NUTS3*	-
	P24	*Number of marina berths, moorings and ashore places / Atlantic NUTS3*	-

***Table 5**. Economic indicators by NACE and ES (extracted fragment, see complete data excel file in separated Appendix)*

NACE	k	economic indicator (a)
03,11	*1*	*V12110*
03,11	*2*	*V12110, CO2*
03,11	*3*	*V12110*
03,11	*4*	*V16110*
03,21	*1*	*V12110*
03,21	*2*	*V12110, CO2*
03,21	*3*	*V12110*
03,21	*4*	*V16110*
08,12	*1*	*V12110*
08,12	*2*	*P9, CO2*
08,12	*3*	*P9*
08,12	*4*	*V16110*
09,90	*1*	*V12110*
09,90	*2*	*CO2*
09,90	*3*	*V12110*
09,90	*4*	*V16110*
30,11	*1*	*V12110*
30,11	*2*	*V12110, CO2*
30,11	*3*	*V12110*
30,11	**4**	**V16110**
30,12	*1*	*V12110*
30,12	*2*	*V12110*
30,12	*3*	*V12110*
30,12	*4*	*V16110*
35,11	*1*	*V12110*
56,30	*3*	*V12110*
93,11	*1*	*V12110*
93,29	*4*	*P24*

__Table 6__. Spatial extent (extracted fragment, see complete data excel file in separated Appendix)

NACE	NUTS	year	sensitivity.numeric	sensitivity.word	extension	spatial.extent
03,11	*FRD1*	*2013*	*2.3980687*	*Medium*	*Widespread*	*0,9*
03,11	*FRD2*	*2013*	*2.3980687*	*Medium*	*Widespread*	*0,9*
03,11	*FRG0*	*2013*	*2.3980687*	*Medium*	*Widespread*	*0,9*
03,11	*FRH0*	*2013*	*2.3980687*	*Medium*	*Widespread*	*0,9*
03,11	**FRI1**	**2013**	**2.3980687**	**Medium**	**Widespread**	**0,9**
03,11	*FRI3*	*2013*	*2.3980687*	*Medium*	*Widespread*	*0,9*
03,11	*IE04*	*2013*	*2.42052451*	*High*	*Widespread*	*1*
03,11	*IE05*	*2013*	*2.42052451*	*High*	*Widespread*	*1*
03,11	*IE06*	*2013*	*2.42052451*	*High*	*Widespread*	*1*
03,11	**PT11**	**2013**	**2.91965917**	**High**	**Widespread**	**1**
03,11	*PT15*	*2013*	*2.91965917*	*High*	*Widespread*	*1*
03,11	*PT16*	*2013*	*2.91965917*	*High*	*Widespread*	*1*
03,11	*PT17*	*2013*	*2.91965917*	*High*	*Widespread*	*1*
03,11	*PT18*	*2013*	*2.91965917*	*High*	*Widespread*	*1*
03,11	**PT20**	**2013**	**2.91965917**	**High**	**Widespread**	**1**
03,11	*PT30*	*2013*	*2.91965917*	*High*	*Widespread*	*1*
03,11	*UKD1*	*2013*	*2.55654464*	*High*	*Widespread*	*1*
03,11	*UKD4*	*2013*	*2.55654464*	*High*	*Local*	*1*

Table 7. Frequency (extracted fragment, see complete data excel file in separated Appendix)

NACE	NUTS	year	freq.numeric
03,21	*FRI3*	*2013*	*1*
03,21	*IE04*	*2013*	*1*
03,21	*IE05*	*2013*	*1*
03,21	**IE06**	**2013**	**1**
03,21	*UKK3*	*2013*	*0.14*
03,21	*UKK4*	*2013*	*0.4*
03,21	*UKL1*	*2013*	*0.2*
03,21	**UKL2**	**2013**	**0.2**
03,21	*UKM6*	*2013*	*0.4*
03,21	*UKM9*	*2013*	*0*
08,12	*IE04*	*2013*	*1*
08,12	**IE05**	**2013**	**0.2**
08,12	*IE06*	*2013*	*0.1*
08,12	*PT11*	*2013*	*0.13*
08,12	*PT15*	*2013*	*0.2*
08,12	*PT16*	*2013*	*0.2*
08,12	*UKK1*	*2013*	*0.5*
08,12	**UKK2**	**2013**	**0.5**
08,12	*UKK3*	*2013*	*0.4*
08,12	*UKK4*	*2013*	*0.15*