A METHOD FOR THE SPATIAL ANALYSIS OF ANTHROPOGENIC PRESSURES IN SPANISH MARINE WATERS

Moreno, I. [1], del Barrio, I. [1], Lloret, A.[1], Perez-Puyol, A. [2]

In 2008, the European Community adopted the Marine Strategy Framework Directive, aiming to achieve or maintain good environmental status in the European marine environment by 2020, applying an ecosystem-based approach to the management of human activities. Spatial information of the distribution of the human activities and their related pressures is essential to accomplish this task successfully. After compiling the available data from official sources, the spatial extent of the land-based and ocean-based human activities that could have an impact on the Spanish marine waters were estimated and mapped using GIS tools. In addition, a series of indexes were created in order to develop a cumulative analysis, taking into account the different relevance of pressures and that single pressures have different intensities. The identification of areas with an accumulation of pressures revealed that it is in coastal waters around big cities where the greater part of the pressures concentrates for each of the five Spanish marine districts. Human impacts emanating from the identified pressures could not be evaluated and this task is proposed to be accomplished in further projects. Nonetheless, the resulting information is considered very useful for managers and technical staff to support not only marine management but also other planning and decision making in Spain.

Keywords: cumulative analysis, pressures, ecosystem-based approach, marine waters

INTRODUCTION

In recent years, an increasing interest in the compatibility of uses involving the ocean, including its protection, has arisen. Since humans depend on ocean ecosystems for important and valuable goods and services (Halpern et al. 2008) and the alteration of the ocean is more evident day after day, policies promoting an ecosystem-based approach to the management of human activities are emerging worldwide, guided by the results of research. In fact, this work has been prepared to meet the requirements of the Directive 2008/56/EC of the European Parliament and of the Council, of 17 June 2008, establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive, MSFD). This Directive aims to protect more effectively the marine environment across Europe by achieving Good Environmental Status of the European marine waters by 2020. More precisely, the objectives of this directive are to (1) protect and preserve the marine environment, prevent its deterioration or, where practicable, restore marine ecosystems in areas where they have been adversely affected and (2) prevent and reduce inputs in the marine environment, with a view to phasing out pollution, so as to ensure that there are no significant impacts on or risks to marine biodiversity, marine ecosystems, human health or legitimate uses of the sea. Marine strategies shall apply an ecosystem-based approach to the management of human activities, ensuring that the collective pressure of such activities is kept within levels compatible with the achievement of good environmental status and that the capacity of marine ecosystems to respond to human-induced changes is not compromised, while enabling the sustainable use of marine goods and services by present and future generations (Art. 3 MSFD; European Commission, 2008). The MSFD was transposed into the Spanish legislation, by Act 41/2010, for the Protection of the Marine Environment. This Act demarcates the Spanish marine waters, which comprise more than a million of square kilometres and are divided into five marine districts (Figure 1). Spain is also involved in two Regional Sea Conventions working for the conservation of the marine environment, namely the OSPAR convention or the Barcelona Convention.

According to the MSFD, member states shall carry out an initial assessment of their marine waters by 2012, taking into account existing data when available and comprising, among other aspects, an analysis of the predominant pressures and impacts, including human activity, on the environmental status of those waters. Human activities interact with the ecosystems via associated drivers of change (Selkoe et al. 2009) and in the context of this work these drivers are equally referred to as pressures or stressors. Understanding the relationship between human activities and their ecological impacts and assessing the spatial distribution of these impacts are crucial steps in managing the use of ecosystems in a way that maximizes societal benefits while minimizing ecosystem degradation (Selkoe el al. 2009).

[1] Centre for Harbours and Coastal Studies, CEDEX, C/ Antonio López 81, 28026 Madrid, Spain. Corresponding mail: ana.lloret@cedex.es
[2] Division for the Protection of the Sea, Ministry of Agriculture, Food and Environment, Plaza S. Juan de la Cruz, Madrid, Spain.

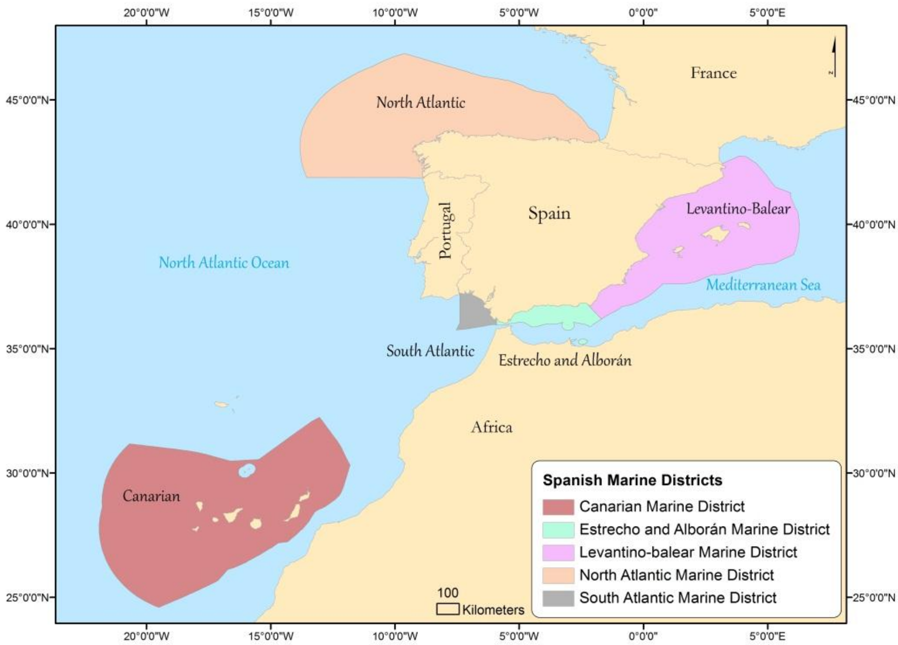

Figure 1. Spanish marine districts

Halpern et al. (2007) defined a standardized, quantitative method, on the basis of expert judgement, to estimate ecosystem-specific differences in the impact of several anthropogenic drivers of ecological change for all the oceans of the world. Since then, this method, or similar ones based on expert judgment as well, have been broadly used by the scientific community, being commonly applied to smaller spatial domains or particular case studies (e.g. Halpern et al. 2009, Selkoe et al. 2009, Ban et al. 2010, Teck et al. 2010, Grech et al. 2012). Some other studies do not assess the importance of the impacts on ecosystems but they deal more specifically with human activities, their extent and their intensity (e.g. Ban and Alder 2008, Benn et al. 2010). The approach of this study is similar to the latest ones and focuses on the human activities affecting the Spanish marine waters. It quantifies the intensity of pressures by means of an analysis of temporal trends and assesses the spatial distribution of the pressures. However, it does not quantify how significant the impacts might be on the surrounding ecosystems due to the lack of a good cartography of habitats covering the whole extent of the Spanish marine districts. This further step will be covered in the near future as long as the necessary information is available. To overcome this limitation, a cumulative analysis of the pressures by means of several indexes, accounting for the different types of impacts, has been developed so as to detect areas susceptible of being impacted.

The main aim of this study is to provide a spatial overview of the distribution and the sum of pressures in each of the five Spanish marine districts, without considering their impacts on specific ecosystem components. Even though more work is needed to completely fulfil the objectives of the MSFD, the temporal and spatial information compiled is vital for the Spanish authorities in order to implement an ecosystem-based management on the Spanish marine waters. Moreover, it is also very helpful for marine spatial planning, a process that informs the spatial distribution of activities in the ocean so that existing and emerging uses can be maintained, use conflicts reduced, and ecosystem health and services protected and sustained for future generations (Foley et al. 2010). The results will also serve as useful information for establishing a baseline condition, one to compare future conditions and to evaluate different management scenarios. Likewise, the spatial information is a powerful tool to be used in environmental impact assessment, or with educational or research purposes. Regarding this, the results will assist researchers in the identification of areas where few stressors are present, which could be recognized as pristine areas from where baselines could be obtained.

METHOD

The method presented here is mainly based on the Baltic Sea Pressure Index (HOLAS project, HELCOM 2010), though adapted to MSDF implementation in the Spanish marine waters, as well as to the available information. The first step to accomplish the objectives of this work was to determine which human activities taking place inland or offshore could be affecting the Spanish marine and coastal waters significantly. Thirty seven stressors were identified, and they in turn are related to twenty seven human activities or sectors. The identification of some other activities likely to be developed in the Spanish maritime areas in the near future was also carried out; offshore wind farms and underground carbon dioxide storage are the activities meeting this classification. The identified stressors may cause just one type of impact or more than one. Besides, each stressor could be associated to one or several human activities. Appendix 1 contains a table showing the relationships established for the Spanish marine environment between human activities, pressures and impacts.

Then, each stressor was thoroughly defined, its related legislation was compiled and definitions of the best possible indicator for every pair stressor-impact were set. For instance the stressor "dumping of dredged material" can cause, among others, smothering and contamination by hazardous substances. The best indicator for the pair dumping of dredged material-smothering is the bottom surface covered with sediments while in the case of dumping of dredged material-contamination it is the load of heavy metals or organic compounds that could be released from the dredged material.

After that, the process of gathering information began with the identification of possible sources of information. To minimize uncertainties, only official sources were considered. According to the Spanish law, the national government is the competent authority for certain activities developed in coastal waters and for all the activities taking place in the territorial sea or within the exclusive economic zone; the regional governments regulate some other human activities in coastal waters, usually related to the management of natural resources, for example, water quality. In addition, the local authorities are also involved since they have to give express consent to some human activities for them to be developed and they manage aspects such as beach cleaning as well. This dispersion of competencies across different governmental entities made the compilation of information extremely difficult. Firstly data was searched on official websites, and then, inaccessible information was requested to the competent authorities.

Data was provided in different electronic formats: reports, MS Excel sheets, shapes, text files, etc. A preliminary analysis of the information was carried out to check whether it covered the most appropriate indicators previously defined. When it was impossible to address them (due to inexistent or inaccessible official information), the indicator was reformulated based on the available data. For example, in the case of dumping of dredged material and smothering, there was no information about the bottom surface that got smothered after every dumping and, only the volume of dumped sediments was known.

Once it was decided which information was to be used for each marine district, a quality control was performed, even though it emanated only from official sources. Then, when possible, two different types of analyses were performed for each indicator: a temporal trend and the spatial extent. To assess the current status of waters and pressures, it was decided that at least 5 years of data should be collected (2005-2009), in order to smooth the influence of extreme events and be able to evaluate trends. Therefore, the temporal analysis was based on this series of years as long as enough data were available. When longer series were supplied, they were included in the assessment as well, to address historical changes in the intensity of pressures.

Regarding the spatial information, the software used for the analysis was ArcGIS 10. In the process of assessing the spatial extent of each activity, we encountered similar problems to the ones faced by Benn et al., (2010). Despite the increasing trend in the administrations distributing the information as GIS datasets, still the majority of the data are offered as text or MS Excel files with XY coordinates for the features. Therefore, the first step to be completed was to transform these formats into a GIS compatible format. Afterwards, spatial data was assigned to their corresponding marine district. The projection (ETRS89) had sometimes to be updated because not all marine districts share the same UTM zone: 30N for the North Atlantic, Levantino-Balear and Estrecho and Alborán districts, 29N for the South Atlantic district and 28N for the Canary Islands district. With all this information, five geodatabases were built, one for each marine district.

The spatial extent of stressors causing physical loss or physical damage was easily assessed for those pressures represented by polygons, for example, artificial reefs, by computing the area that they occupied. When stressors were depicted as lines or points, it was necessary to establish a buffer to compute area values. For more of the assets, the radio used to build buffer polygons was sought in the literature or it was based on expert criteria. However, for some datasets, and to continue with the above example, like dumping of dredged material, we had a list of coordinates for several of the sites and just one position for the others. With the lists, polygons were created and their area computed. The average of the areas was assimilated to a circle and its radio was used to buffer the sites represented by points. In this way, an estimation of the total surface and the percentage of the marine district affected by each stressor were obtained. Additionally, the total surface that could be affected by physical loss or physical damage was estimated for every marine district.

For the stressors causing other impacts, like pollution, the evaluation of the volumes of water that could be disturbed became difficult since it depends not only on the characteristics of the human activities but on the local hydrodynamics (currents, waves, tides, etc.). The extent of the Spanish coastline (~ 7000 km length), the large number of sources of disturbances, and the lack of detailed information about these sources, discouraged us to use models to assess this parameter in this preliminary assessment. Some other authors deal with this problem by using simplifications. For example, Ban et al. (2010) assume a linear decay from the origin of the activities. As these authors state, this solution entitles some problems because the linear decay assumes that the stressors diffuse equally in all directions, when in fact currents and river plumes are likely to influence de diffusion of stressors. Similarly, not enough is known about the effects of some of the stressors to apply specific functions for each type of stressor. Due to the drawbacks of the linear decay, a more simple solution was adopted and most of the stressors were presented just as points or lines, depending on its nature. For the cumulative analysis, as it is explained later in more detail, an area of influence for each stressor was defined by buffers. The only stressor for which a linear decay is supposed in the cumulative analysis is submarine noise.

Next in order was assessing the current status of the stressors, by examining their spatial distributions and their temporal trends and, eventually, a cumulative analysis was performed for every type of impact defined in the Table 2, Annex 3 of the Marine Strategy Framework Directive and for every marine district. A 5 by 5 minutes grid was created in order to facilitate this analysis. The total number of assessment units in the Spanish marine waters is 16400 with areas that range from less than 1 km^2 (near the shoreline) up to 83 km^2 in the open sea. The approach is different for the 2 groups of stressors previously defined. For those pressures for which the area of affection could be estimated we computed 1) the total sea-floor area possibly affected by all the pressures causing the considered type of physical disturbance 2) the percentage of sea-floor area affected in each marine district, 3) the modified area in each assessment unit and 4) the percentage of sea-floor area affected in each assessment unit. For the rest of them a semi-quantitative index was created, based in the presence, absence or the proximity of pressures. For those stressors located in the sea a presence/absence criterion was normally set due to the size of the assessment units; for those stressors located inland the criterion used was based on proximity because there is a need to account for the radius of influence of the pressure and for the distance between the source of disturbance and the shore. This occurred, for example, with urban and industrial discharges: while the location of the plants was well known, the location of the discharges was not. The indexes compute the sum of the stressors present in each assessment unit weighted by certain scores reflecting which stressors are more likely to cause harm to the marine environment. To account for the intensity of stressors and when the stressors have a wide range of values, more than one category was set within the same stressor, the different categories having different weighting scores. Based on the values obtained for each index, and for each marine district, a scale with five ranges of potential accumulation of stressors was set. Areas where a relevant number of the highest class assessment units gathered were highlighted as areas with a high potential risk of suffering harmful effects while, assessment units belonging to the second highest class were supposed to have a moderate potential risk. In this way, the main human threats to the Spanish coastal and marine environments were identified as well as their distribution.

In this first assessment of the Spanish marine waters, a very simple approach to the analysis of impacts was carried out. It determines the benthic habitats possibly affected by physical loss or damage by superimposing the cartography of habitats with those units assessed as with a high or very high probability of accumulation of stressors. More complex methodologies, like the one presented by Halpern et al. (2008), are likely to be applied for the next revision of the Spanish Marine Strategy as long as more detailed information on ecosystems and pressures is available.

RESULTS

Results show that, for all marine districts, stressors tend to concentrate in the inner continental shelf, more precisely in coastal waters. Only activities like fishing, navigation, exploitation of oil and gas and the laying of submarine cables tend to affect outer waters. Similarly, it can be inferred from the results that there are human activities that could be causing disturbance in all the marine districts, while some other activities are more important in a specific marine district than in the others.

Stressors causing physical disturbance

For the analysis of pressures related to physical disturbance, several groups of stressors were distinguished depending on their effects: those affecting the sea-floor, those modifying the hydrographical properties of marine waters, those generating submarine noise and those introducing litter into the sea.

The first set of stressors mentioned above included those causing physical loss and physical damage. It has to be highlighted that the spatial extent of these stressors is very small in comparison to the total extent of the different marine districts when the abrasion due to bottom trawling is not considered (Table 1). Due to the harmful effects of the use of this gear on the sea floor, it was decided to evaluate it separately, since the extent of sea floor that could result affected is at least two orders of magnitude greater that the one potentially affected by the rest of stressors of this group. Although this practice is non-existent in the Canary Islands region, it is prevalent in the rest of the marine districts. The number of cells in which the bottom trawling fishing effort is greater than 500 hours per year is 694, adding up a surface of 58428 km^2. Also remarkable is the length of coastline altered due to the construction of infrastructures related to commercial or recreational navigation, fishing or the maintenance of beaches. According to some data from the Instituto Hidrográfico de la Marina (not published), the shoreline of Spain considered as artificial coast (harbours, marinas and defensive structures) has a length of 1671 km (about 15% of the total shoreline length). Following the results of the EUROSION project, 756 km of the Spanish shoreline is in erosion, most of it located in the Mediterranean littoral and the Gulf of Cadiz (708 km). Figure 2 focuses on sealing and it shows the surface potentially sealed and the cell´s surface potentially affected by sealing in the South Atlantic marine district.

Table 1. Sea bottom area (km^2) and percentage of the total marine district area potentially affected by physical pressures in the Spanish marine districts

Marine District	Smothering		Sealing		Abrasion		Selective Extraction	
	Area	%	Area	%	Area	%	Area	%
North Atlantic	186,82	0,06	49,84	0,02	344,38	0,11	209,75	0,07
South Atlantic	119,48	0,80	39,37	0,26	204,46	1,37	118,02	0,79
Estrecho and Alborán	112,90	0,44	27,95	0,11	128,34	0,50	15,08	0,06
Levantino-Balear	246,54	0,11	93,96	0,04	379,82	0,16	226,59	0,10
Canarian	75,67	0,02	14,92	0,01	No data	-	No data	-
Spain	741,43	0,07	226,12	0,02	1057,01	0,1	569,44	0,05

The evaluation of submarine noise was mainly based on AIS and VMS signals sent by ships. Therefore, areas of accumulation of noise corresponded with the most important routes of commercial vessels, traffic separation schemes, fishing grounds and the harbours surroundings. The greater values of the index appear in the zone of the Strait of Gibraltar (Figure 2). Modelling of submarine noise should be tackled in future revisions of the Spanish Marine Strategy.

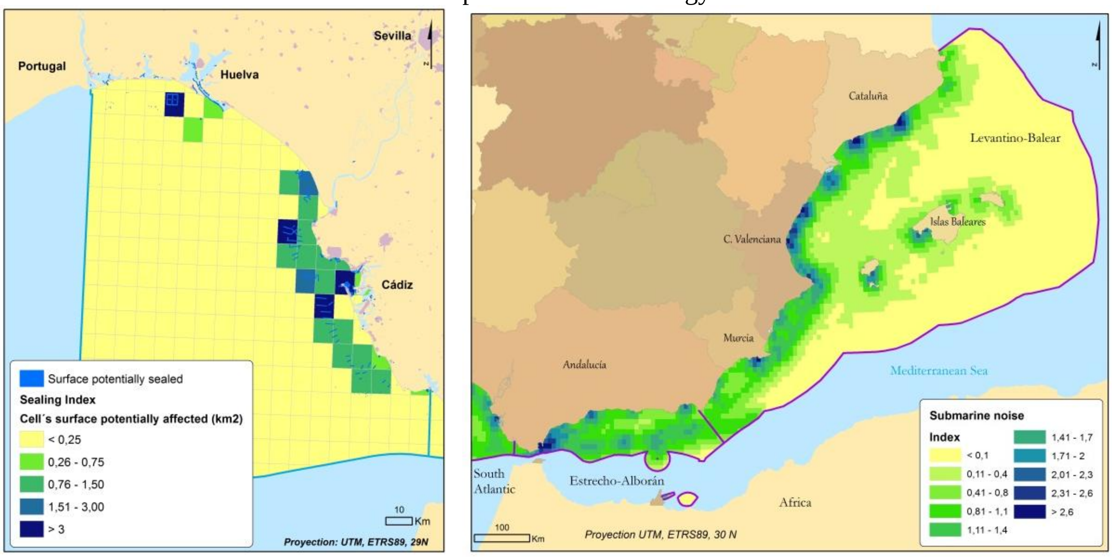

Figure 2. Index results for sealing in the South Atlantic marine district (left) and submarine noise in the Mediterranean Sea (right)

The cumulative analysis of the activities modifying the salinity or temperature of the sea water shows them to be mostly located inland, and due to the local effect they have, the consequences at a scale of marine district are not significant. The main modifiers of salinity and temperature in the Mediterranean coastal waters of Spain are dams built in the past to guarantee the availability of fresh water to the population and the harvests throughout the year.

With regard to the littering of the seas, the main sources of litter are identified: permanent population of coastal towns, tourists, ports and vessels. The result of assigning each of them a radius of action and a weight depending on their magnitude is shown in Figure 3, but only for those activities located inland. The areas where litter is more likely to enter the sea are big cities and some seaside resorts.

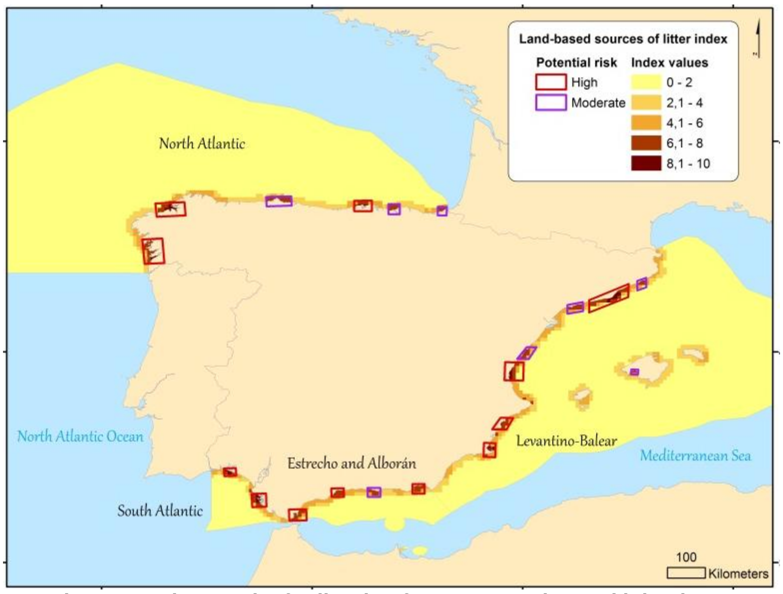

Figure 3. Index results for littering from sources located inland

Stressors causing chemical disturbance

The cumulative analysis was performed separately for loads of contaminants and nutrients, without distinguishing between different types of substances. The stressors tend to accumulate near big cities, where most of the industrial and wastewater discharges gather. Depending on the amount of sources, the area is classified as with a moderate or a high potential risk of input of high loads of contaminants/nutrients. Table 2 shows the number of areas of each category identified in every marine district. The North Atlantic and the Levantino-Balear districts are the ones where contamination is more expected, which is coherent with the fact that they are the districts where the majority of the industrial activity takes place. To illustrate this, the grid for the North Atlantic district is shown in Figure 4. Offshore activities with a low probability of spillage but with a high potential risk of damage, like oil platforms, have been identified separately, as they have not been considered as relevant areas in the cumulative analysis.

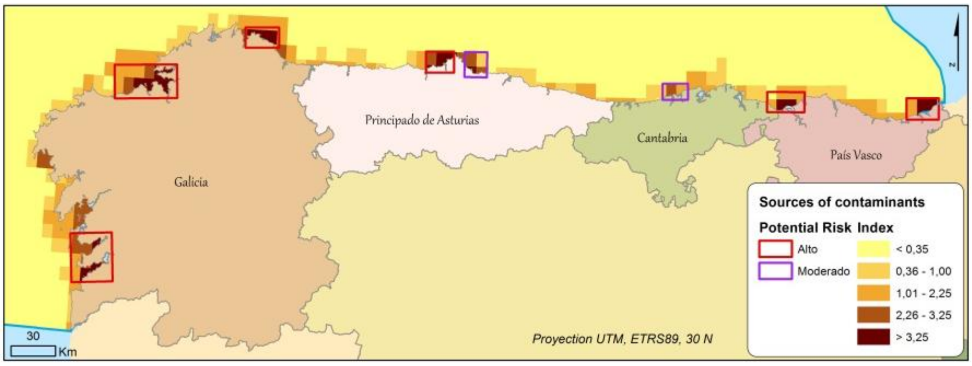

Figure 4. Index results for contamination

Stressors causing biological disturbance

The introduction of microbial pathogens takes place in Spain mainly through waste water discharges, river mouths, bathing sites and fish farming (Figure 5). The identification of the areas of occurrence of multiple stressors is carried out, and the Estrecho an Alborán and the Canarian districts are the ones with a greater number of areas of risk (Table 2). However, pollution due to pathogens is currently more related to spillages from the sources rather than due to their regular functioning, and therefore it is difficult to predict where contamination because of pathogens is going to occur.

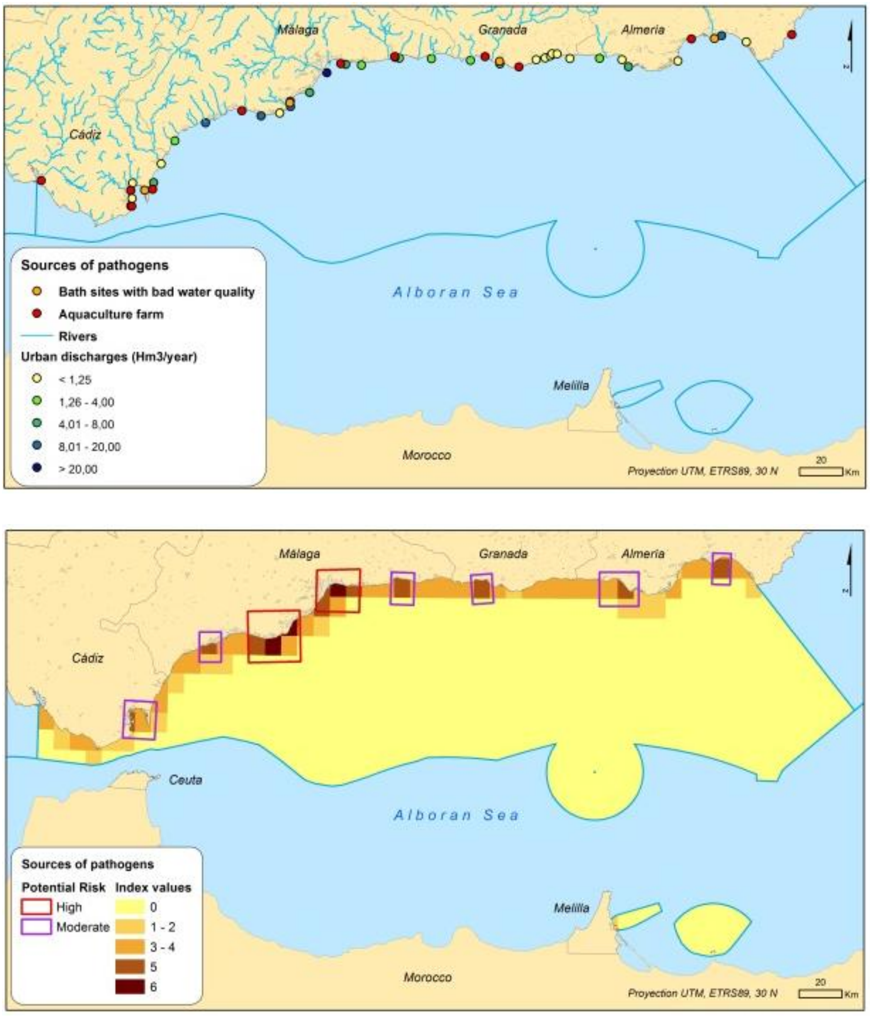

Figure 5. Sources of pathogens (top) and result for pathogens index (bottom)

The lack of information about sources of non-indigenous species and translocations led us to focus this stressor on structures related to commercial and recreational navigation (ballast waters and incrustations): harbours, marinas, single-buoy moorings, ports of anchorage, etc. The sites that accumulate some of these infrastructures are the ones that have been highlighted. They are more common in the Levantino-Balear and the North Atlantic districts (Table 2).

The cumulative analysis could not be carried out for fishing due to the different nature of the target species for the different gears. Individual analyses of the fishing effort for the different gears showed that, bottom trawling firstly and, purse seiner secondly, are the most important gears in all marine districts except for the Canary Islands, where drifting longlines represent the maximum fishing effort.

Table 2. Number of areas with a moderate or a high potential risk of entrance of stressors causing chemical or biological disturbance

Marine District	Pollution		Nutrients		Pathogens		Non-indigenous species	
	Moderate	High	Moderate	High	Moderate	High	Moderate	High
North Atlantic	2	6	6	3	3	2	3	4
South Atlantic	1	1	2	2	0	1	1	2
Estrecho & Alborán	2	1	4	1	6	2	2	1
Levantino-Balear	0	5	7	2	3	2	4	2
Canarian	0	0	2	1	4	3	1	1
Spain	5	13	21	9	16	10	11	10

DISCUSSION

While the results described above represent to date the best estimation available of the distribution of the human activities affecting the Spanish marine waters, key information needed to fully characterize these anthropogenic activities accordingly to the purpose of the MSFD is not always existent or regularly recorded. And, evidently, the quality of the results depends on the quality of the input data. Regarding this, the resolution and the accuracy of the existent data vary, among the activities and, from place to place. For example, the analyses of heavy metals due to riverine inputs are performed by different laboratories for the different rivers and, not all of them have the same limit of detection for each metal. This limit could be also different from one year to the next one within the same laboratory, as long as an improvement of the equipment takes place. Another issue to consider is that data is compiled to be used at a regional scale. For more detailed studies, associated to marine protection areas or specific sites, information at a smaller scale should be gathered. Besides, the spatial information available for each marine district is not the same, and therefore, the results of the indexes are not comparable between marine districts. The homogenization of the information is desirable so as to be able to assess the Spanish marine waters as a sole entity in order to be able to prioritize actions between different marine areas successfully. In this first spatial assessment, historical pressures were not taken into account and only the most recent data available is used. Therefore, no dynamic processes are captured and no spatial comparison with former status of the human activities is possible at this point. But the MSFD mandates member states to submit similar analysis every six years and thus, this first assessment is crucial since it will serve as a baseline for the subsequent ones.

But there are limitations not only related to the compilation of information, but also regarding the proposed method. One of them is the weight given to the different pressures. Another one is that the buffers used for mapping the stressors are mainly based on expert criteria and sometimes, they do not take into account the intensity and the duration of the pressures due to the lack of information. Modelling may be considered to solve this problem. It is very useful to delineate the extent of pressures and, hence, it provides an excellent tool to avoid buffers and to fill the gaps encountered. However, modelling requires a great effort and it would not be recommended in every case due to the different spatial scales considered in this work. Thermal discharges are a good example to illustrate this. They reach the equilibrium with the surrounding marine waters in hundreds of meters while the grid cells are approximately 8 by 8 km. In this context, modelling would be more appropriate for river discharges or changes in hydrodynamics due to interference with new large infrastructures, which have greater extent. Ideally, nested grids should be used in the future, with smaller cells covering the coastal area as pressures concentrate mostly there and, in this way, also dealing adequately with the modelling of stressors with a small spatial extent.

All the pressures mentioned in the indicative list of Annex III, Table 2, of the MSFD have been addressed in this work. However, other organizations, like the OSPAR convention, of which Spain is contracting party, are working with a wider list of pressures. Some of these "extra" pressures were incorporated to our analysis, like hydrological changes or turbidity, but for most of them, like climate change stressors, hypoxia or light pollution, no enough information was available.

As it can be inferred from the above, knowledge of human activities and pressures on the marine environment needs still to be improved. However, and despite the results being constrained by data and methodology, they still constitute the most important compilation of information on human activities influencing the Spanish marine waters. The identification of the areas where pressures tend to accumulate enables us to determine “hot spots” on which to focus the future analysis of impacts and also pristine areas, to establish reference values.

The analysis of the predominant pressures and impacts requested by the MSFD should also cover the main cumulative and synergetic effects. There is still a great uncertainty about these effects on marine waters and significant gaps exist in this area. Crain et al. (2008) synthesized 171 studies that manipulated two or more stressors in marine and coastal systems and found that cumulative effects in individual studies were additive (26%), synergistic (36%), and antagonistic (38%). Most of these studies were conducted in the lab (73%). These authors emphasized the necessity of improving the knowledge about the response of communities and ecosystems and how multiple stressors interact at the different ecological levels, since this is crucial for an adequate management of the marine environment.

CONCLUSIONS

The information related to the human activities taking place in the Spanish seas is sparse and currently, not enough to properly assess all the pressures and impacts that they produce on the marine environment. Despite this constraint, the identification of possible vulnerable areas, where an important number of pressures causing the same kind of impact superimpose, was successfully accomplished. This study reveals that the majority of the human activities causing physical and chemical pressures are present mostly on the most inner continental shelf, usually near big cities coasts, while biological impacts affect larger areas due to fishing and navigation. This analysis will assist in resolving conflicts among the human uses of the marine environment and will facilitate the development of effective management plans. The identification of gaps of information will serve to design monitoring programmes and programmes of measures to efficiently deal with the assessment of pressures and, in the near future, of impacts as well. Likewise, a better coordination between all the administrations involved in the management of the seas is necessary to facilitate this task. Additionally, more detailed information about the distribution of marine habitats is essential, at least in areas where a high number of pressures is present, to successfully accomplish the analysis of impacts there. Even though further research is needed to fully understand the relationship between human activities and impacts, the first steps have already been taken and will be useful, not only to succeed in achieving a good environmental status of the marine waters by 2020 but also in favouring the maritime spatial planning of the Spanish waters.

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Annex 1

Impacts / Pressures			Human Activity
Physical Loss	Smothering	Sand mining and sediment dredging	Coastal defence and ports activity
		Disposal of dredged material	Port activity
		Beach nourishment and construction of artificial beaches	Tourism and coastal defence
		Cables and pipelines	Goods transport, telecommunication networks, sanitation
		Artificial reefs and controlled sinking of ships	Fishing management, environmental management, coastal defence
	Sealing	Harbour and coastal structures	Ports activity, coastal defence
		Oil exploration and exploitation Offshore platforms and single buoy mooring	Energy Industry
		Artificial reefs and controlled sinking of ships	Fishing management, environmental management, coastal defence
		Offshore wind farms	Energy Industry
Physical Damage	Changes in siltation	Harbour and coastal structures	Coastal defence and ports activity
		Rivers regulation	Water supply for population and agriculture
		Beach nourishment and construction of artificial beaches	Tourism and coastal defence
		Mussel farming	Aquaculture
		Disposal of dredged material	Ports activity
		Artificial reefs and controlled sinking of ships	Fishing management, environmental management,
		Sand mining and sediment dredging	Coastal defence and ports activity
	Abrasion	Bottom trawling fishing	Commercial fishing
		Anchoring	Goods and passenger transport, sailing and fishing
		Sand mining and sediment dredging	Coastal defence and ports activity
	Selective extraction of non-living resources	Sand mining and sediment dredging	Coastal defence and ports activity
		Oil exploration and exploitation	Energy Industry

Impacts / Pressures			Human Activity
Other physical disturbances	Submarine noise	Cables and pipelines (construction)	Telecommunication networks
		Seismic surveys	Research
		Oil exploration and exploitation	Energy Industry
		Disposal of dredged material	Ports activity
		Sand mining and sediment dredging	Coastal defence and ports activity
		Harbour and coastal structures, marine works	Coastal defence, ports activity and industry
		Shipping	Vessels traffic: goods, passengers, recreational boating, commercial fishery
	Marine litter	Marine litter	Tourism, commercial fishery, Vessels traffic: goods, passengers, recreational boating, urban solid waste management
		Wrecks	Vessels traffic: goods, passengers, recreational boating, commercial fishery
		Dumped munitions and munitions dumpsites	Military activity
	Other physical disturbances	Offshore permanent structures	Safety, industry
		Sand mining and sediment dredging	Coastal defence and ports activity
		Carbon capture and storage	Energy industry, activities against climate change
		Sea water extraction	Desalinization, salt production and industrial refrigeration
Interference with hydrological processes	Significant changes in thermal regime	Thermal discharges	Power plants and other industries
	Significant changes in salinity regime	Brine discharges	Desalinization
		Freshwater discharges	Coastal waste water treatment plants and untreated urban discharges
		River regulation	Water supply, energy production and agriculture
Contamination by hazardous substances	Introduction of synthetic and non-synthetic compounds	Accidental spills	Industry, shipping
		Diffuse pollution from atmospheric deposition	Industry, transport

Impacts / Pressures			Human Activity
		Diffuse pollution from runoff	Agriculture, mining e industry
		Riverine discharges	Industry, agriculture, sanitation
		Intentional discharges	Industry, sanitation
		Disposal of dredged material	Port activity
	Introduction of radio-nuclides	Direct discharges	Nuclear power plants
		Freshwater discharges	Nuclear power plants
Nutrient and organic matter enrichment	Inputs of fertilizers and other nitrogen- and phosphorus-rich substances	Direct discharges (solids and liquids)	Industry, sanitation
		Riverine discharges	Industry, agriculture, sanitation
		Farming of fish, shellfish and seaweed	Aquaculture
		Diffuse pollution from atmospheric deposition	Industry, transport
		Diffuse pollution from runoff	Agriculture and industry
	Inputs of organic matter	Farming of fish, shellfish and seaweed	Aquaculture
		Riverine discharges	Industry, agriculture, sanitation
		Incidental non-target catches	Commercial and recreational fishing
		Urban waste water discharges	Sanitation
		Disposal of dredged material	Port activity
		Sand mining and sediment dredging	Coastal defence and ports activity
		Beach nourishment and construction of artificial beaches	Tourism and coastal defence
Biological disturbance	Introduction of microbial pathogens	Urban waste water discharges	Sanitation
		Ballast waters	Shipping
		Bathing sites	Tourism and recreation
		Riverine discharges	Sanitation
		Farming of fish, shellfish and seaweed	Aquaculture

Impacts / Pressures			Human Activity
	Introduction of non-indigenous species and translocations	Hulls and anchors	Shipping, anchoring
		Ballast waters	Shipping
		Farming of fish, shellfish and seaweed	Aquaculture
		Offshore platforms and single buoy mooring	Industry
		Disposal of dredged material	Ports activity
		Escapes from aquariums	Recreation and research
	Selective extraction of species	Extraction of species with a commercial interest	Commercial fishing
		Farming of fish, shellfish and seaweed	Aquaculture
		Harvesting of shellfish	Harvesting of shellfish
		Recreationally extraction of species	Recreation
		Incidental non-target catches	Commercial fishing