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# A matter of scales: Does the management of marine recreational fisheries follow the ecosystem approach to fisheries in Europe?

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ABSTRACT

European policy-makers are increasingly aware of the ecological and socioeconomic relevance of marine recreational fisheries (MRF), but there are still gaps in the information needed to achieve sustainable management. How is the current management of European MRF performed? Is it promoting the Ecosystem Approach to Fisheries (EAF)? The management of MRF in Europe was reviewed by analyzing how different European regulations align with the EAF in different geographic and administrative scales. Text mining tools were used to identify key concepts and analyze the text of legal regulations on MRF in the European Union (EU), Portugal, Spain and the United Kingdom (UK). Also, the Ecosystem Fisheries Legal Assessment (EFLA) framework was used to assess the alignment of the regulations with the EAF. The number of regulations about MRF in Spain and Portugal is higher than in the UK and the EU, probably because the relative higher importance of regional regulations in Spain and Portugal, and the limitations imposed to recreational fishers in marine protected areas (MPAs). The lack of specific regulations on MRF in the EU, and open-access in the UK for recreational fishers, except for Atlantic salmon *Salmo salar*, explain their lower number of regulations. The EFLA framework showed that the European public policies on MRF follow the EAF principles. Enough attention is payed to ecological components, but socio-economic sustainability could be improved. However, policy efficiency could be lower than expected because potential institutional misfits derived from the eventual confluence of different spatial scales.

## 1. Introduction

### 1.1. Marine recreational fishing in Europe

Marine recreational fishing is an important and popular leisure activity in most coastal areas around the world, with high number of participants and significant economic and social impacts. In Europe it is estimated that around nine million Europeans engage in marine recreational fisheries (i.e., 1.6% of the total European Union (EU) population), resulting in 78 million fishing days, generating six billion euros in new capital annually and millions of related jobs [1]. A similar pattern of the socioeconomic importance of recreational fishing is observed in other developed countries (e.g., [2,3] and is estimated to be increasing rapidly in developing countries [4,5]). There is also increasing evidence on the potential importance of recreational fishing, with estimated catches for particular areas and species of similar magnitude to those reported for the commercial fishing sector (e.g., [6–8]).

Despite recent improvements [9,10], many of the EU fisheries resources remain below levels that are capable of producing maximum sustainable yield, and with exploitation rates above the scientifically recommended [11–13]. A number of these stocks are shared across

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neighboring countries and captured by the commercial and recreational sectors, causing additional challenges in their management, e.g., in the case of Atlantic cod *Gadus morhua* [1,14,15]. In addition, there is a growing perception on the need to take into account indirect impact from recreational fisheries in the ecosystems (e.g., on the food webs, habitats structure, etc.) [16–19].

Despite their importance, Marine Recreational Fisheries (MRF) have been traditionally neglected in favor of commercial fisheries when it concerns to both data collection efforts to obtain information about the activity and management. In many European countries, specific and detailed information about both the economic and biological effects of MRF is still insufficient to support adequate fisheries management [1,8,20]. With the growing interest that has been observed for MRF in recent years, the EU has been calling for more regular and adequate information on the activity of marine recreational fishers to better manage the shared fisheries resources and meet the interests of the various players in the fisheries landscape [21]. Member States are now required under the Data Collection Framework (DCF) to routinely report on annual recreational catches and releases for Atlantic bluefin tuna *Thunnus thynnus*, Atlantic cod, Atlantic salmon *Salmo salar*, European sea bass *Dicentrarchus labrax*, European eel *Anguilla anguilla*, and elasmobranchs to improve the assessment and management of these species [22,23]. However, there are still many gaps in the understanding, assessment, and management of this sector in European waters [1,20].

### 1.2. The ecosystem approach to marine recreational fisheries

Implicitly or explicitly, the majority of the recently implemented instruments of relevance to fisheries promote an approach to fisheries giving more attention to the ecosystem [24]. The term “Ecosystem Approach to Fisheries” (EAF) was adopted by the FAO Technical Consultation on Ecosystem-based Fisheries Management held in Reykjavik in 2002. The term “approach” indicates that the concept outlines a way of considering ecosystem considerations into traditional fisheries management [25,26].

Most of the principles and conceptual elements of an EAF are already included in several arrangements, agreements, conventions, codes, etc., of direct or indirect relevance to fisheries, e.g., the encouragement of ecosystem protection by the conservation of biodiversity, of habitats and of natural variability, the reduction of the impacts of fishing on a multispecies basis under a precautionary approach, or the promotion of adaptive governance within clear boundaries and jurisdictions. These instruments span from the 1982 UN Convention on the Law of the Sea, to the 1995 FAO Code of Conduct for Responsible Fisheries, and its International Plans of Action, and from the 1971 Ramsar Convention, to the 1992 Convention on Biological Diversity (CBD), the 1995 Jakarta Mandate on Marine and Coastal Biological Diversity, the 2001 Conference on Responsible Fisheries in the Marine Ecosystem, and the 2002 World Summit on Sustainable Development, among others [27].

During the past two decades, renewed interest for a more ecological approach to fisheries has emerged inter alia in Australia, with the application of the Ecologically Sustainable Development (ESD), in the North Pacific, the Northeast Atlantic, and the Antarctic [24]. The EU policies are also aligning with international dynamics for the implementation of the EAF by focusing on the need to consider trade-offs among environmental, social, economic and objectives explicated to interested stakeholders for a better decision-making process [28]. When setting priorities for the EAF, policy makers need to pay careful attention to transboundary fish stocks, small-scale fisheries and coastal areas. For example, Buhl-Mortensen et al. [29] designed a framework to monitor and assess spatially managed areas in nine marine areas of 13 European countries. The framework follows several steps to operationalize EAF and improving “traditional management” by considering the local context, the data collection of relevant ecosystem information, human activities and management goals, the selection of indicators, and the development of a risk analysis with the evaluation of management effectiveness.

In relation to the EAF applied to MRF, it is important to highlight that MRF are often given low priority to other marine uses [30,31]. This arises in part because the data-poor environment in which MRF is still managed in Europe, in many cases with limited access to reliable information on long-term and current catches and effort, and on economic and social values [20]. The lack of consistent, coherent and stable sources of information on MRF and the confluence of access of marine recreational fishers with other users of European marine ecosystems jeopardizes the implementation of the EAF to MRF [20]. Furthermore, the meaning of some of the principles of the EAF still remain elusive for many scientists because the need to develop active transdisciplinary approaches, and in consequence they are difficult to apply for managers and policy-makers dealing with MRF. In consequence, there is a need to 1) recognize the impacts of MRF on the ecosystems; 2) develop a standardized collection of information on the ecological, biological, social and economic dimensions of MRF; and 3) provide a set of clear objectives to implement EAF-policies to MRF. Otherwise, the operationalization of the EAF in MRF will remain as a big challenge for policy-makers, marine recreational fishers and other stakeholders [17].

### 1.3. Objective of this study

A critical review of the current management of MRF in Europe is presented by analyzing how different European regulations on MRF align with the EAF in different geographic and administrative scales. The text of the legal regulations on MRF in the EU and in a selection of Member States have been analyzed, and tested the Ecosystem Fisheries Legal Assessment (EFLA) framework proposed by Castillo et al. [32] to assess their proximity with EAF principles.

In recent years policy-makers have been reacting to the certainty that there is growing need to improve long-term sustainability of complex Socio-Ecological Systems (SES) like MRF by a wiser use of scientific advice, by considering fisheries impacts in an ecosystem context, integrating different administrative levels, or by incorporating bottom-up management approaches [33–35]. Therefore, in a context of increasing use of European marine ecosystem services that is leading to cumulative conflicts between groups of stakeholders [20,36], this study will allow to know if MRF are currently managed in Europe as part of a socio-ecological system aiming for ecological and socio-economic sustainability.

## 2. Materials and methods

### 2.1. Case studies

Legal regulations on MRF in Europe published by public administrations of the EU and by national and regional administrations of Portugal, Spain and the United Kingdom (UK) have been analyzed in this study (Fig. 1). These countries have been selected because they cover a broad latitudinal gradient: from the North (the UK) to the South (Portugal and Spain) of Europe. Furthermore, a relevant European socio-political-environmental gradient (from the Atlantic to the Mediterranean) have also been included in the analysis. Moreover, a wide range of differences will be considered in relation to (1) fisher's access, i.e., from countries with high rates of recreational fishers in relation to their population like the UK to countries with lower rates, such as Spain [1]; (2) cultural and other motivations for practicing marine recreational fishing, e.g., while in the UK and other countries of northwest Europe (e.g., Ireland, France and Norway), catch and release is a conservation and aesthetic measure with an increasing practice, in Portugal and Spain it is a minority option because most fishers consume their catches [20,37]; and (3) the number and types of regulations, e.g., from countries with few regulations and restrictions, like the UK [38], to

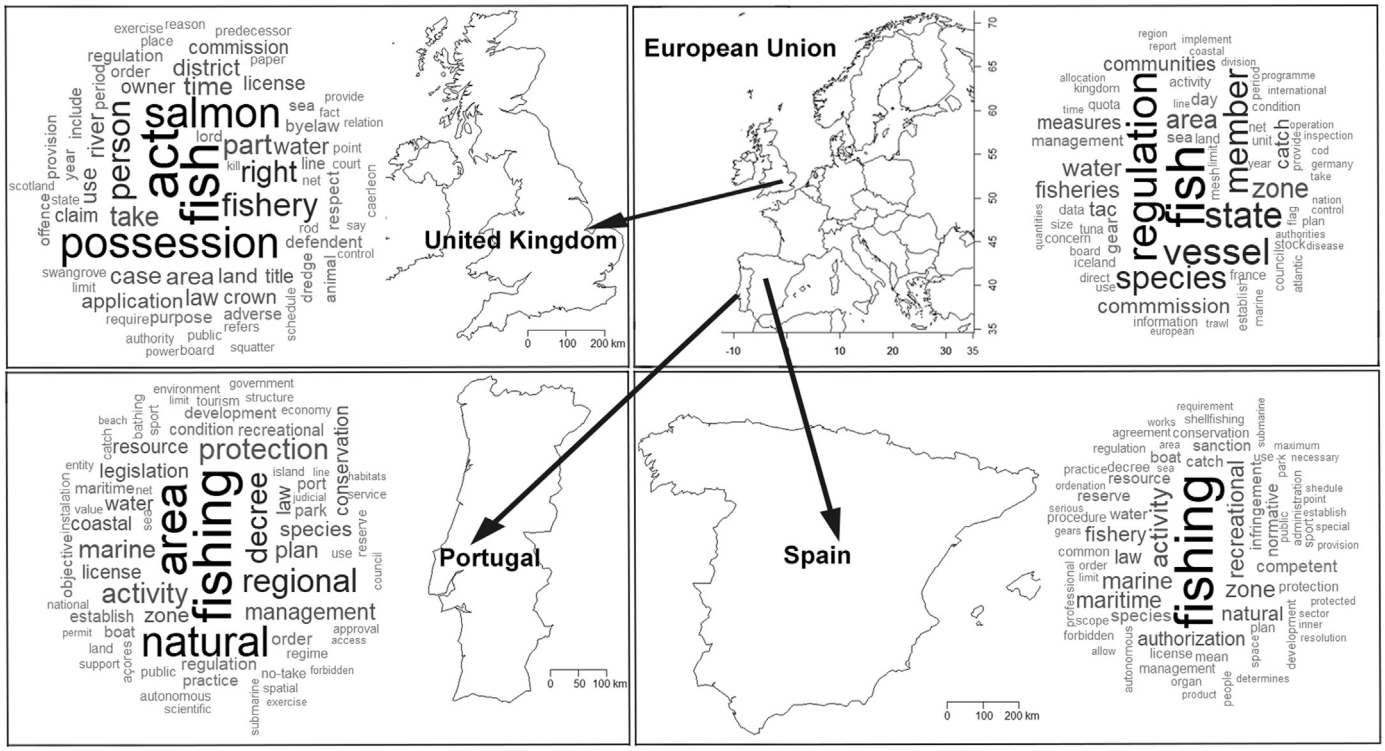


**Fig. 1.** Frequent words included in legal regulations about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom. Letter size and color strength refers to relative frequency. Only the 70 most frequent words were plotted.

countries with an increasingly complex core of laws and restrictions, like Spain and Portugal [20,39].

### 2.2. Inclusion criteria for the legal regulations

In the analyses, only regulations currently in place have been included (up to the end of year 2015), only excluding those current regulations that are a partial update of older versions (in these cases the original valid regulation has been included). The articles of the regulations that were not applicable to MRF, e.g., related to inland fishing, to the regulation of commercial fishing, or other human activities, were excluded from the analysis. Moreover, in the case of Spain, specific legislation on taxes and operational regulations about sport federations have not been included. In the case of the UK court decisions have been included because they are part of the legal framework.

### 2.3. Search engines and selection criteria for legal regulations

Different legal search engines and search criteria (keywords to match with the title and/or the text of regulations) have been used in this study to collect the legal regulations on MRF. Moreover, expert opinion of the authors was also used to include the legislation on MRF that for some reason did not show in the results provided by the legal search engines. This resulted in three additional regulations to be included for Spain regarding minimum size landings of fish species and, one regulation in the UK regarding catch restrictions for some fish species.

In the case of the EU, a free online database (available at http://eur-lex.europa.eu) and a commercial legal database (Westlaw Next) were used with the same criteria in both cases (Table 1). The first search provided 91 regulations and the second 31 regulations. After filtering to eliminate duplicates and regulations for freshwater bodies, 27 regulations were obtained. In Portugal, a free government online database was used (available at https://dre.pt/web/guest/pesquisa-avancada) (Table 1). The search provided 914 regulations, that after filtering were reduced to 97 results. In Spain, both a free government online database (available at https://www.boe.es/legislacion/legislacion_ava.php) and a commercial legal database (Westlaw Aranzadi) have been used with the same search criteria (Table 1). The first search provided 512 regulations and the second 32 regulations. After filtering, 231 regulations were obtained. Finally, in the UK, a commercial legal database (Westlaw Next) was used with two different sets of search criteria (Table 1). The first search provided 57 regulations and the second 197. After filtering, 41 regulations were obtained.

### 2.4. Key concepts and discourse of legal regulations

The legal frameworks in the EU and of each of the case studies (Portugal, Spain and the UK) were analyzed by using text mining tools [40] included in the statistical package R [41]. Thus, to identify and analyze the main concepts included in the text of the legal regulations, the texts of the legal articles of each area were pooled into a single file and the relative frequency of each of the words was obtained by using the *termdocumentmatrix* tool included in the *tm* library [42]. Usual stop words were removed by using the tools *stopwords* and *removeWords* of the *tm* library. Thereafter, to obtain a first illustration about the content of the legal frameworks in each area, the frequencies of recurrent words (frequencies ≥ 0.19% of total) were plotted, after translation into English in the case of Portuguese and Spanish regulations, with the *wordcloud* tool of the *wordcloud* library [43]. In a second step, the meaning of the concepts represented by the most frequent words was analyzed by showing the connections between the six most frequent words included in the text of the regulations by using the *Rgraphviz* library [44]. The maximum correlation threshold was used in each case, allowing at least one association between the words. Furthermore, the three main topics in each legal framework were identified by using the *LDA* tool of the *topicmodels* library, that generated a probabilistic framework for the frequency occurrences of the more relevant three words of the regulations [45]. Finally, it was performed a hierarchical cluster analysis on the dissimilarity matrix of the most recurrent words in the

**Table 1**
Search criteria and online databases used to obtain regulations about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom.

| Region | Search criteria | Online database | Regulations (N) |
|---|---|---|---|
| European Union | "recreational fishing", OR "spear fishing", OR "rod and line fishing", OR "spearfishing", OR "sport fishing" | EUR-Lex | 91 |
| | | Westlaw Next | 31 |
| Portugal | "pesca" (fishing) AND "recreativa" (recreational), OR "lúdica" (leisure), "desportiva" (sport), OR "apeada" (from the shore), OR "submarina" (spear fishing), OR "embarcada" (from boats) | DRE | 914 |
| Spain | "pesca recreativa" (recreational fishing), OR "pesca deportiva" (sport fishing), OR "pesca de recreo" (recreational fishing), OR "pesca submarina" (spear fishing), OR "pesca marítima recreativa" (marine recreational fishing) OR "pesca marítima deportiva" (marine sport fishing), OR "pesca marítima de recreo" (marine recreational fishing), OR "pesca con caña" (line fishing) | BOE | 512 |
| | | Westlaw Aranzadi | 32 |
| United Kingdom | "recreational fishing", OR "sport fishing", OR "spear fishing", OR "spearfishing", OR "rod and line fishing" "angler" OR "angling" AND "marine" OR "sea" | Westlaw Next | 57 |
| | | | 197 |

regulations (approx. 30 words for each legal framework) applying Ward's minimum variance method [46].

### 2.5. Compliance with the ecosystem approach to fisheries

To assess the degree of alignment of fishing regulations with the EAF, the EFLA framework was used in this study [32]. A total of 57 criteria, modified from Castillo et al. [32], and aimed to cover the main socio-ecological dimensions of MRF, were used to score each regulation (Table 2). If one regulation met the requirements included in a given criterium one point was scored, and zero points were assigned if the criterium was not accomplished by the regulation. The criteria were grouped into five components, fishing (15 criteria), environmental-ecological (12 criteria), institutional (13 criteria), economic (6 criteria) and social (11 criteria) (Table 2).

The final scores were used to obtain the Policy Component Scores (PCS) for each category $j$ as follows:

$$PCS_j = \frac{1}{n} \sum X_i \quad (1)$$

were $X$ corresponded to the value (0 or 1) that each $i$ criterion adopted for the given component and $n$ is the total number of criteria. Thereafter, the average PCS were used to assess the overall alignment with ecosystem-based management by obtaining the Integrated Policy Legal Index (IPLI):

$$IPLI = \frac{1}{k} \sum PCS_j \quad (2)$$

Were $PCS_j$ was the PCS of the j component and k represents the total number of components.

Finally, a hierarchical cluster analysis on PCS values was performed with *fpc* library [47] of R [41] to analyze the similarity between the legal frameworks of the different cases of study, using Euclidean distance and Ward's clustering criterion [46].

## 3. Results

### 3.1. The regulation of marine recreational fisheries in the European Union, Portugal, Spain and the United Kingdom

The number of regulations with references to MRF was very different in each of the studied areas: the legal framework was larger in Spain (231 regulations), followed by Portugal (97 regulations), the UK (41 regulations), and the EU (27 regulations). The number of regulations produced by the central and regional administrations was also very different in each case study. Only 6% of the regulations in Spain were adopted by the Spanish Government, while the other 94% derived from 11 different regional administrations. In the UK 10% of the analyzed regulations were from the Government of the UK (22% when excluding court decisions), while most of the regulations (90% or 78%, respectively) were from five regional administrations. In Portugal 53% of the regulations on MRF were from the Government of Portugal, while the remaining 47% were from two regional administrations.

#### 3.1.1. The legal framework about marine recreational fisheries in the European Union

The relationships between some of the most frequent words included in the EU regulations, i.e., "member" and "state" showed that MRF in the EU largely depends on the Member States (Fig. 2). However, other very frequent words included in the EU legal framework, e.g., "fish", "species" and "vessel" were related to the fact that the EU has some regulations on the characteristics and use of the fishing vessels, and on the fishing of some fish species that affect MRF (Fig. 2). Thus, frequent works like "gear" were related to the management of the vessels, while "quota" and "TAC" were related to limits imposed to the catch of some fish species (Fig. 1). In this sense, "cod" and "tuna" were the most cited fish species in the EU regulations (Fig. 1). Furthermore, other frequent words like "data" were associated to the data needs for MRF included in the DCF regulations.

The main topics identified in the EU legal framework also highlight that the management of MRF is mainly exerted by Member States (topics 2 and 3) (Table 3). Moreover, topic 1 was related to the European management of the fishing possibilities of the stocks of some transboundary species (Table 3).

The same two main groups could also be identified in the hierarchical cluster of the frequent words of the EU regulations: the cluster related with the management by Member States is defined by the words "member" and "state", among other, while "fish" and "regulation" define the European management of shared fish stocks (Fig. 3a).

Since MRF in the EU is mainly regulated by the Member States, it is not surprising that there were not specific regulations about MRF in the EU; thus, MRF norms were mainly included under the regulation of general marine fishing activities (44% of the analyzed regulations) and on the regulation of some fish species (30%) (Table 4). On the other hand, public and animal health, fish imports, and disease control, were also relevant for the regulation on MRF (15%) (Table 4); in fact, the word "disease" was among the frequent words included in the EU regulations (Fig. 1).

#### 3.1.2. The legal framework about marine recreational fisheries in Portugal

Highly frequent words included in the analyzed Portuguese regulations were related to the management of MRF in marine protected areas (MPAs), e.g., "area" and "natural" (Fig. 2). Furthermore, frequent words like "conservation", "habitats", "no-take", "park", "protection" and "reserve" could also be linked to the creation and management of MPAs, and to specific restrictions to MRF in these (Fig. 1). In addition, two of the three main topics identified in this legal framework (topics 1 and 2) (Table 3), and one of the groups obtained after the clustering of frequent words, defined by the words "area" and "natural", were also related with the management of MRF in the Portuguese MPAs (Fig. 3b). Therefore, regulations on conservation and on MPAs management were almost half (46%) of the regulations about MRF in Portugal (Table 4). On the other hand, the fisheries management in the two autonomous

**Table 2**
Criteria template modified from (Castillo et al., 2016) used to analyze whether legal frameworks support the Ecosystem Approach to Fisheries. A tentative comparison of the relationships with the principles of the Institutional Analysis and Development Framework proposed by [54,55] and modified by [56] was also included (1 A = User boundaries: Clear boundaries between legitimate users and nonusers must be clearly defined; 1B = Resource boundaries: Clear boundaries are present that define a resource system and separate it from the larger biophysical environment; 2 A = Congruence with local conditions: Appropriation and provision rules are congruent with local social and environmental conditions; 2B = Appropriation and provision: The benefits obtained by users from a common-pool resource (CPR), as determined by appropriation rules, are proportional to the amount of inputs required in the form of labor, material, or money, as determined by provision rules; 3 = Collective-choice arrangements: Most individuals affected by the operational rules can participate in modifying the operational rules; 4 A = Monitoring users: Monitors who are accountable to the users monitor the appropriation and provision levels of the users;4B = Monitoring the resource: Monitors who are accountable to the users monitor the condition of the resource; 5 = Graduated sanctions: Appropriators who violate operational rules are likely to be assessed graduated sanctions (depending on the seriousness and the context of the offense) by other appropriators, by officials accountable to the appropriators, or by both; 6 = Conflict-resolution mechanisms: Appropriators and their officials have rapid access to low-cost local arenas to resolve conflicts among appropriators or between appropriators and officials; 7 = Minimal recognition of rights to organize: The rights of appropriators to devise their own institutions are not challenged by external governmental authorities; 8 = Nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises).

| Criterium | Content | IAF |
|---|---|---|
| | *Fishing* | |
| 1 | Regulates the use of inappropriate practices and fishing gears not compatible with resource conservation and responsible MRF | 2A |
| 2 | Promotes compatibility and development of MRF and other uses, like commercial fishing, among others | 1A |
| 3 | Avoids the catch of juvenile fish of species targeted by recreational fishers | 2A |
| 4 | Promotes minimum catch sizes for MRF based on L100 criteria or higher when overfishing evidences are detected | 2A, 4B |
| 5 | Regulates maximum catch sizes for MRF to preserve old and very large individuals | 2A |
| 6 | Controls the use of selective recreational gears and practices based on hook size and type, hanging coefficient, catch and release, baiting, etc. | 2A |
| 7 | Eliminates the excessive recreational fishing effort | 2A, 4B |
| 8 | Regulates the capture of bait species for MRF | 2A |
| 9 | Ensures periodic collection of statistical data on catches and effort of MRF | 4B |
| 10 | Ensures collection of social and economic information on MRF | 4B |
| 11 | Regulates fishers' participation into the collection of MRF information | 4B |
| 12 | Applies precautionary measures for MRF based on preset reference levels for different fishery parameters | 2A, 4B |
| 13 | Applies precautionary measures on resources exploitation by MRF based on new methods of fishing and/or catch | 2A |
| 14 | Develops participative and adaptive fisheries management plans for MRF | 3 |
| 15 | Regulates MRF effort and catch based on ocean dynamic regimes and climatic factors | 2A |
| | *Environmental–Ecological* | |
| 16 | Protects and preserves free connectivity between habitats of marine ecosystems relevant to MRF | 2A |
| 17 | Maintains natural ocean dynamic cycles relevant to MRF | 2A |
| 18 | Preserves critical habitats for migration, reproduction, growth, feeding, etc., of fish species with ecological and socio-economic relevance for MRF | 1B |
| 19 | Includes a precautionary approach related to potential negative impacts of MRF | 2A |
| 20 | Reduces pollution, wastes and discards related to MRF | 2A |
| 21 | Creates and manages MPAs with different categorization and management policies for MRF | 1B |
| 22 | Develops research and decision-making policies that relate environmental trends and climate changes with MRF management | 2A |
| 23 | Preserves biodiversity and protect endangered fish species or with special categorization | 1B |
| 24 | Recovers or re-establishes overfished, reduced or depleted species of interest for MRF inhabiting the fishing areas | 1B |
| 25 | Regulates fish culture and exotic species introduction relevant to MRF | 1B |
| 26 | Protect fish assemblages structure in fishing areas relevant to MRF | 2A |
| 27 | Protects species of ecological and conservation relevance (bioengineering, key species, highly endemic) for MRF | 1B |
| | *Institutional* | |
| 28 | Creates and regulates the effective functioning of advisory fisher councils composed by the main stakeholders involved in the fishery, including recreational fishers | 3, 7 |
| 29 | Creates and regulates the effective functioning of specific government agencies to regulate and manage MRF | 4A, 8 |
| 30 | Ensures the provision of human, logistic and economic resources to guarantee the correct functioning of MRF management agencies | 8 |
| 31 | Promotes the development of local institutions to improve the governance processes and to contribute in a more efficient management of MRF | 3, 7 |
| 32 | Creates and regulates suitable mechanisms and best practices for solving disputes based on environmental and man-made impacts affecting fishing rights of recreational fishers | 5, 6 |
| 33 | Promotes interinstitutional relationships among different agencies related to management and governance of MRF at different levels | 8 |
| 34 | Articulates regulatory measures and management of fish stocks among regions or neighboring states in order to ensure the sustainable use of transboundary and migratory resources relevant to MRF | 4A, 4B, 8 |
| 35 | Ensures free access to general and specific fishery regulatory norms for MRF | 3 |
| 36 | Creates and regulates advisory mechanisms to guarantee public participation in decision-making processes, law and management policy development of MRF | 3 |
| 37 | Implements exclusive fishing rights on the resources of MRF when is needed or appropriate | 1A, 2B |
| 38 | Ensures access to the recreational fishing areas for native and local communities | 1A, 2A |
| 39 | Regulates the use of port facilities for MRF | 1A |
| 40 | Supports community waters and fisheries tenure, resource access and use rights for MRF | 1A, 2A, 2B |
| | *Economic* | |
| 41 | Allow fundraising to support the MRF sector | |
| 42 | Articulates administrative measures that ensure an economically viable exploitation for MRF | |
| 43 | Promotes economies related to MRF activities | |
| 44 | Facilitates the access to soft loans for the development of activities related to MRF | |
| 45 | Applies precautionary measures for MRF based on preset reference levels for different economic parameters | 2B |
| 46 | Promotes funding and financial incentive mechanisms for environmental protection, including compensation and payment for ecosystem services by recreational fishers | 2B |
| | *Social* | |
| 47 | Guarantees the use of traditional recreational gears, fishing boats compatible with local fishing practices and the provision of fishing licenses for MRF | 1A, 2A |
| 48 | Promotes measures to obtain and apply fishers' ecological knowledge (FEK) and traditional fishing technologies in resources management of MRF | 2A |
| 49 | Promotes measures that take into account recreational fishers' interests and demands | 3 |
| 50 | Creates and regulates mechanisms to solve conflicts related to management and governance processes of MRF | 5, 6 |

(*continued on next page*)

**Table 2** (*continued*)

| Criterium | Content | IAF |
|---|---|---|
| 51 | Promotes training of recreational fishers in technical aspects related to fish handling | |
| 52 | Supports and preserves knowledge, culture, traditions and practices of native people and local communities regarding MRF | 7 |
| 53 | Guarantees appropriate health and hygienic standards in handling and consuming the recreational catches | 2A |
| 54 | Establishes controls that verify levels of harmful substances for human consumption in fish caught by recreational fishers | 2A |
| 55 | Applies precautionary measures for MRF based on preset reference levels for different social parameters | 1A, 2A |
| 56 | Promotes gender equity and ensures women participation in MRF | 2A |
| 57 | Guarantees special rights to vulnerable people including women, children, ethnic minority groups and native people in case of environmental impacts, climatic hazards, and loss of fishing grounds and fishing areas access of MRF | 1A, 2A |

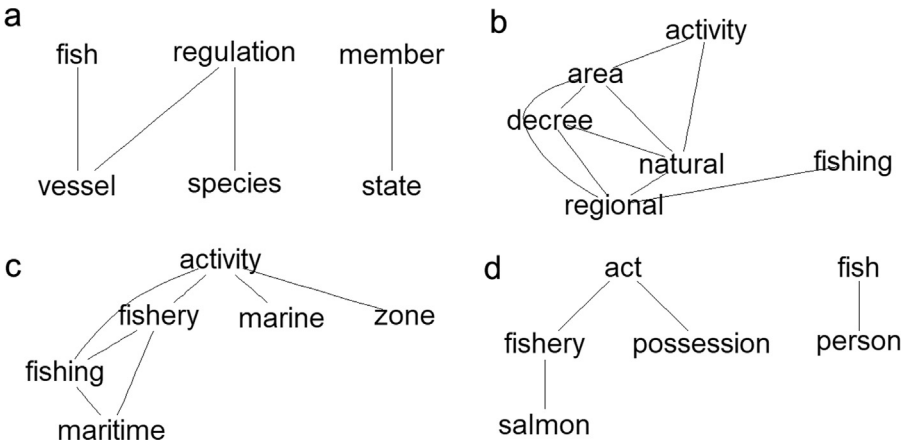


**Fig. 2.** Diagram showing relationships of the six most frequent words used in texts about marine recreational fishing regulations in the European Union (a), Portugal (b), Spain (c), and the United Kingdom (d). Maximum correlation threshold has been used to show the relationships between words with the condition that all words showed at least one relationship with another word.

**Table 3**
Main topics identified in the legal regulations about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom, based in the frequency occurrences of the more relevant words.

| Region | Topic | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| European Union | Regulation | State | Fish |
| | Fish | Member | State |
| | Vessel | Coastal | Member |
| Portugal | Natural | Area | Fishing |
| | Area | Natural | Regional |
| | Protected | Plan | Port |
| Spain | Fishing | Natural | Fishing |
| | Maritime | Activity | Fishery |
| | Marine | Fishing | Infraction |
| United Kingdom | Possession | Fish | Salmon |
| | Act | Right | Act |
| | Area | Salmon | Fish |

administrative regions in Portugal, i.e. Azores and Madeira, was related to the association showed between some of the other most frequent words included in the Portuguese regulations on MRF, i.e., “fishing” and “regional” (Fig. 2). In this sense, the frequent use of the words “Açores” and “autonomous” also referred to the separation of regional fisheries management in Portugal (Fig. 1). Regional management was also included in the last of the main topics identified in the Portuguese legal framework about MRF (topic 3) (Table 3). Moreover, unlike in the EU, MRF has been specifically regulated in Portugal (5% of the regulations) (Table 4); thus, frequent words like “boat”, “catch", ”forbidden”, “license”, “permit” or “species” (Fig. 1) were related to these, and/or to regulations on species and on minimum landing sizes (3%) (Table 4). Finally, the management of MRF under regulations on coastal management of urban and rural areas (25%), port regulations (5%) and tourism regulations (5%) (Table 4) was associated with other frequent words like “bathing”, “beach”, “port” and “tourism” (Fig. 1).

### 3.1.3. The legal framework about marine recreational fisheries in Spain

Frequent words in the Spanish regulations about MRF such as “area”, “conservation”, “park”, “protected” and “reserve” could be related to the regulation of MRF in the Spanish MPAs (Fig. 1). Furthermore, the topic 2 (Table 3), and one of the identified clusters characterized by the presence of the word “conservation” (Fig. 3c) were also associated to MPAs regulations. Thus, the management of MRF in MPAs and other conservation-oriented regulations were the main objectives (49% of the regulations) of the analyzed Spanish legal framework (Table 4). On the other hand, the overall management of MRF was well developed in the Spanish legal framework (17% of total), and in addition to the management of general marine fishing and of some species, formed a relevant core of regulations (41%) (Table 4) that was identified in the topics 1 and 3 (Table 3), and in the cluster distinguished by words like “fishery”, “recreational”, or “species” (Fig. 3c). Frequent words in the text of the regulations, like “boat”, “catch”, “forbidden”, “gears”, “infringement”, “license”, “recreational”, “sanction”, or “species”, and very frequent words like “fishery” and “fishing” (Fig. 2) were also associated to the management of marine recreational fisheries.

### 3.1.4. The legal framework about marine recreational fisheries in the United Kingdom

The word “salmon” was one of the most used words in the regulations on MRF in the UK (Fig. 1). The use of this word was highly correlated to other largely used words like “fishery” and “possession” (Fig. 2), what was related to the management of fishing rights to harvest this fish species. Other frequent words like “area”, “district”, “license”, “owner” or “river”, were associated to the management of Atlantic salmon fisheries, private or managed communally in many cases, in districts that mainly cover fresh water bodies, but also estuaries and adjacent coastal areas (Fig. 1). Common words like “court”, “defendant”, “lord” or “offense” were associated with the numerous legal actions on the fishing rights of this fish that were included in the analysis (Fig. 1). Thus, topics 2 and 3 were directly associated to the management of Atlantic salmon, but topic 1 was also related to this

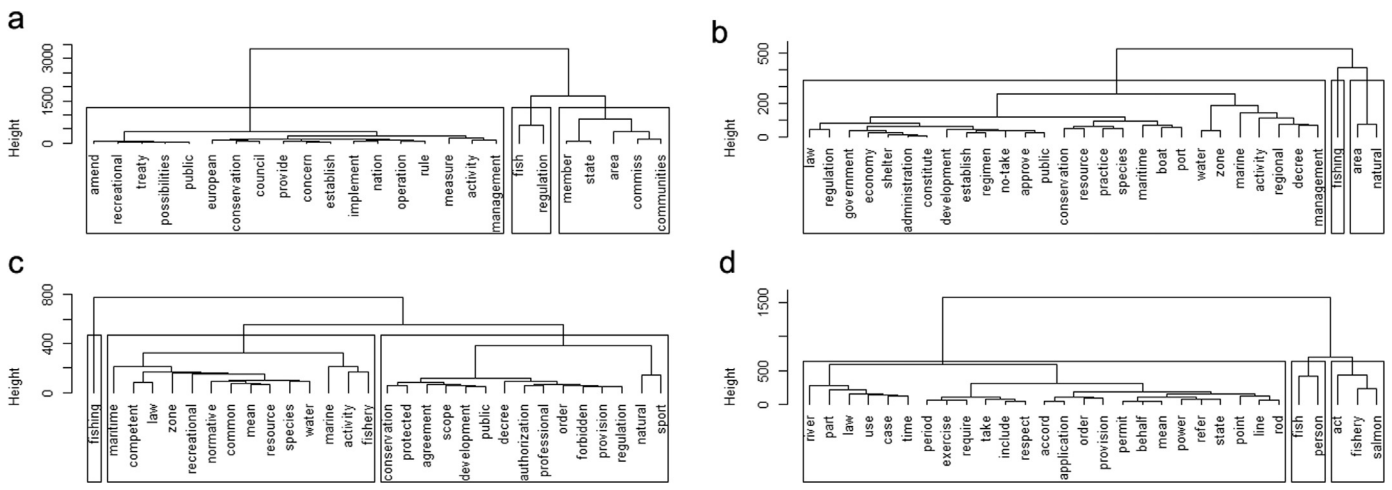


**Fig. 3.** Cluster dendrogram showing relationships of the most frequent words (≈30) used in texts about marine recreational fishing regulations in the European Union (a), Portugal (b), Spain (c), and the United Kingdom (d). Boxes show the three clusters considered in the analyses.

species (Table 3). Furthermore, two of the three clusters that included the words "person", and "salmon" respectively, were also associated to fishing rights for Atlantic salmon (Fig. 3d). Therefore, regulations on this and on a few other fish species were the main objective of the analyzed legal framework on MRF in the UK (61% of the regulations) (Table 4). Moreover, some of the regulations in the UK were created to manage specifically MRF (10%), or to manage MRF under the general management of marine fishing (17%) (Table 4). Noticeably, norms about MRF under the management of the welfare of animals were also relevant in the UK (7%) (Table 4). In this sense, frequent words like "animal" or "kill" could be associated to these regulations (Fig. 1).

### 3.2. Policy component scores and integrated policy legal index in the European Union, Portugal, Spain and the United Kingdom

Regarding the degree of compliance of European fishing regulations with the EAF by using the EFLA framework, the PCS obtained for institutional criteria were the same (0.92) in the different studied areas, while they were highly similar for environmental-ecological criteria: highest in Portugal and Spain (1.0), and slightly lower in the EU (0.92) and in the UK (0.83) (Fig. 4). The PCS on fishing, economic and social criteria were more variable among the different areas. Thus, PCS on fishing criteria was higher in Spain (1.0), in Portugal (0.93), and in the EU (0.87), and lower in the UK (0.67); PCS on economic criteria was high in the UK (1.0), and in the EU and Spain (0.83), but low in Portugal (0.50); and finally, PCS on social criteria was high in the EU (0.82), relatively high in Portugal and Spain (0.73), while only achieved 0.36 in the UK (Fig. 4).

Based in the PCS for each region, the IPLI scored in Spain and in the EU was higher than the IPLI obtained in Portugal and in the UK (Fig. 4). Thus, the Spanish and the EU legal frameworks were the more prepared for the developing of an ecosystem-based management of MRF, followed by the Portuguese and by the UK regulations (Fig. 5).

## 4. Discussion

### 4.1. The ecosystem approach to fisheries in the management of marine recreational fisheries in Europe

In general, the legal frameworks of the EU, Portugal, Spain and the

**Table 4**
Number and relative frequency (%) by main objectives of legal regulations about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom.

| Objective | Region | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | European Union | | Portugal | | Spain | | United Kingdom | |
| | N | % | N | % | N | % | N | % |
| Coastal activities | 3 | 11.1 | 24 | 24.7 | 5 | 2.2 | 1 | 2.4 |
| Conservation | 0 | 0.0 | 3 | 3.1 | 5 | 2.2 | 0 | 0.0 |
| Disease control | 1 | 3.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Fish imports | 2 | 7.4 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Fishing competences | 0 | 0.0 | 5 | 5.2 | 13 | 5.6 | 0 | 0.0 |
| Marine fishing | 12 | 44.4 | 4 | 4.1 | 33 | 14.3 | 7 | 17.1 |
| Minimum landing sizes | 0 | 0.0 | 1 | 1.0 | 3 | 1.3 | 0 | 0.0 |
| MPA | 0 | 0.0 | 42 | 43.3 | 108 | 46.8 | 0 | 0.0 |
| Navigation | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |
| Ports | 0 | 0.0 | 5 | 5.2 | 2 | 0.9 | 1 | 2.4 |
| Public and animal health | 1 | 3.7 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Recreational fishing | 0 | 0.0 | 5 | 5.2 | 40 | 17.3 | 4 | 9.8 |
| Species | 8 | 29.6 | 2 | 2.1 | 18 | 7.8 | 25 | 61.0 |
| Sports | 0 | 0.0 | 1 | 1.0 | 1 | 0.4 | 0 | 0.0 |
| Tourism | 0 | 0.0 | 5 | 5.2 | 1 | 0.4 | 0 | 0.0 |
| Weapons | 0 | 0.0 | 0 | 0.0 | 1 | 0.4 | 0 | 0.0 |
| Welfare of animals | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 3 | 7.3 |
| Total | 27 | 100.0 | 97 | 100.0 | 231 | 100.0 | 41 | 100.0 |

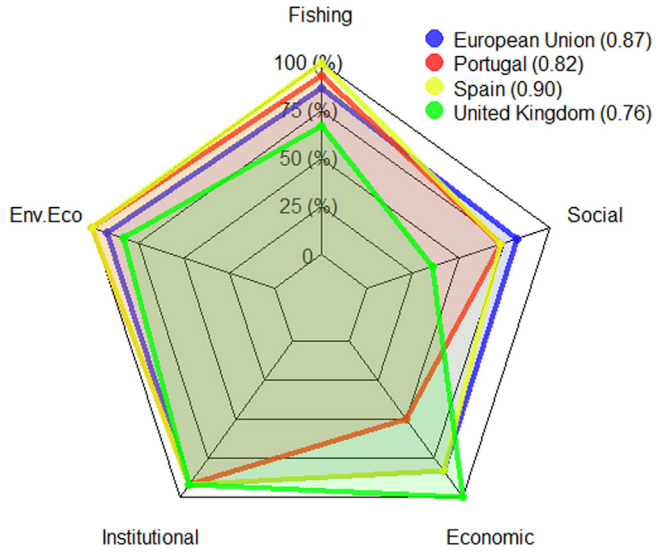


**Fig. 4.** Estimated Policy Component Scores for five main components: economic, environmental-ecological (Env. Eco), fishing, institutional and social, and Integrated Policy Legal Index values (in brackets) used to assess the degree of compliance of the legal frameworks about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom with the Ecosystem Approach to Fisheries.

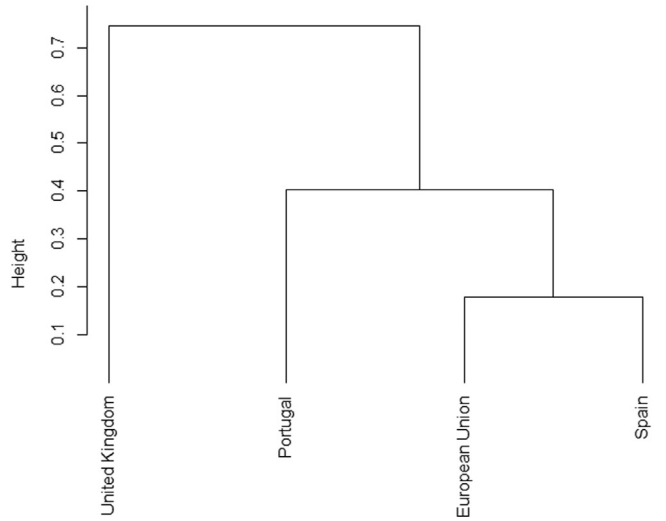


**Fig. 5.** Cluster analysis based on the estimated Policy Component Scores similarity obtained to assess the degree of compliance of the legal frameworks about marine recreational fishing in the European Union, Portugal, Spain and the United Kingdom with the Ecosystem Approach to Fisheries.

UK shows relatively high IPLIs,[1] which suggests a high willingness towards the development of public policies that follow the EAF principles in the management of MRF. It is a better result than the one obtained by Pitcher et al. [48] for Spain (near acceptable) and the UK (poor), and in general for developed European countries. The 10 years between Pitcher et al. study and ours, the use of different conceptual frameworks, and especially the fact that Pitcher et al. included all marine fisheries in the analyses, would explain the differences. Moreover, the Ecosystem Fisheries Legal Assessment (EFLA) framework developed by Castillo et al. [32] and used in this study allows comparisons between different geographic and temporal scales. In this sense, the legal frameworks about fisheries management studied by Castillo et al. [32] in Argentina showed much lower IPLI values than in this study.[2] The willingness of European regulations to adopt EAF-oriented policies for MRF is probably related to the effort that has been made in the last years by the EU institutions to promote sustainable uses of marine resources [49] and ecosystems [50,51]. Furthermore, EAF policies have been also progressively introduced in the scientific institution leading fisheries research and advice in Europe, namely the International Council for the Exploration of the Sea (ICES) [52]. Therefore, the high values of the PCS showed in this study for institutional criteria (Fig. 4) highlight the current strong sensibility towards the inclusion of the EAF principles in the fisheries regulations for MRF across Europe.

The role of MPAs in the protection of biodiversity makes them a central paradigm of the EAF [24,27]. The large number of regulations in Portugal and Spain about the management of MRF in MPAs (Table 4) is likely one of the main triggers for the higher values obtained by both countries in the PCS for environmental and ecological criteria (Fig. 4). Many of these regulations limit the access and some practices of recreational fishers in MPAs. Conversely, none of these MRF-related limitations on MPAs were identified in the analyzed legislation of the EU, or in the UK, which could partially explain the lower scores obtained in both cases (Fig. 4).

The reason why the legal frameworks in Portugal, and especially in Spain, showed a high willingness towards the EAF is not related to the larger number of regulations in these countries, because the EU scored relatively high (Fig. 4) with a significant lower number of regulations (Table 4). The differences between the analyzed regions in the management of MRF under an EAF perspective showed in this study (Fig. 5) are mainly based in the differences observed in the PCSs on fishing, economic and social criteria. Thus, attending to the fishing criteria, MRF has been specifically regulated in Portugal, Spain and in the UK, while only indirectly in the EU. The higher scores obtained in Portugal and Spain could be explained by the mandatory licensing scheme, and to limitations fishing effort, catches and methods and gears included in the legislations of these countries, which are supported by most of the fishing criteria (Table 2). Moreover, data needs for recreational catches under the EU DCF were probably behind the relatively high PCS obtained by the EU in relation to fishing. Although some fisheries regulations on MRF have been developed in the UK, accounting for 27% of total (Table 4), there are less limitations to the practice of MRF than in Portugal or Spain. For example, no license is needed for marine recreational fishing and there are no bag limits in place, except those for the protection of fishing rights for Atlantic salmon. These factors probably explain the lower score in the fishing criteria showed by the UK legal framework (Fig. 4). However, because MRF in the UK tends to be a mostly catch and release practice, catch regulations are probably not as needed as in Portugal or Spain, where most catches are retained [37]. The UK also obtained the lower PCS on social criteria. Therefore, there is room to increase the involvement of the recreational fishers in an adaptive and sustainable management of fisheries and ecosystems in the UK (other than Atlantic salmon), as supported by the criteria on this topic (Table 2). Conversely, the UK is the only case that reached the maximum value in the economic PCS, reflecting the economic importance given to this activity in the country. Moreover, the low economic PCS suggests that there is room for the promotion of MRF-related economies in Portugal (Fig. 4).

### 4.2. Use opportunities of the ecosystem fisheries legal assessment

The EFLA framework provides a rich core of criteria that have been already applied in the study of the fishing regulations in large and complex administrative areas [32]. Although it was initially developed for the analysis of freshwater commercial fisheries, the EFLA

[1] IPLI can range from 0 to 1, being 1 the optimum. In this study, values were between 0.76 and 0.90 (Fig. 4).

[2] [32] reported values below 0.5 in all cases.

framework was easily adapted for this study to MRF by using 58 of the original 62 criteria, and introducing minor changes in the remaining (see Table 2 and Castillo et al. [32] to compare both sets of criteria). This simple adaptation of the EFLA to MRF have been probably facilitated because the EFLA was based on the efforts made by the United Nations Food and Agriculture Organization (FAO) to review the concepts and paradigms under the EAF to enable its implementation to worldwide fisheries [27]. In fact, many of the EFLA criteria are also part of the principles included in the FAO Code of Conduct for Responsible Fisheries [53]. Therefore, by using the adapted criteria of the EFLA framework, biophysical (geographical, ecological and biological aspects), social and economic attributes (from all stakeholders involved) and attributes of the governance system were identified and analyzed in the regulations included in the European legal frameworks about MRF. Furthermore, EFLA incorporated principles of other frameworks that have been specifically proposed to incorporate the human dimension in the study of the management of common-pool fisheries, like the Institutional Analysis and Development Framework (IAD) [54,55]. All of the principles proposed by [56] in their IAD have been covered by the modified EFLA criteria used in this study (Table 2). Therefore, in practice, the EFLA framework provides a solid base to analyze the potential sustainability of some of the main components of complex SES [35,57–59]. Attending to the results obtained here (Fig. 4), it seems that European regulations about MRF are paying suffice attention to ecological components, but the attention to the socio-economic sustainability of the system could still be improved.

### 4.3. Scales and institutional fit

It was shown in this study that there were some differences in the current adaptability of the analyzed legal regulations on MRF to EAF, with the Spanish and the EU regulations better positioned than others (Fig. 5). However, there has been no attempt in this study to establish hierarchies in the goodness of the legal systems regarding the EAF. On the contrary, the greatest interest of the results of this study lies in the opportunities to improve public policies in the cases where lower compliance with the EAF principles have been detected.

It should be stressed that the regulations considered in this study operate at different geographic scales. For example, MRF is not directly managed at the EU level, and regulations affecting MRF have been found under other regulations on coastal and rural activities, disease control, seafood imports, marine fishing, public and animal health, and conservation of certain species (Table 4). Comparisons between different geographical scales, with a wide range of legislative requirements should be made with caution. In this sense, the differences between the Atlantic and Mediterranean regions were not analyzed due to the limited geographical coverage of the selected case studies. However, the incorporation of different geographical scales was essential in the analysis. For instance, the potential institutional fit has not been fully incorporated in relation to the geographical scales of this study. Although higher-order national laws tended to unify fisheries management at the country level, the incorporation of the regional legislations, highly relevant e.g. in the case of Spain, with 11 different regions, could show a more complex scenario, with regional differences in the application of the EAF principles in the management of the MRF. Furthermore, by-laws[3] were not included in this analysis because the lack of comprehensive legal search engines at the municipality level. Since by-laws are well developed, e.g. in the UK, where include regulations on management of public recreation areas, their inclusion could have contributed to some changes in the results of this study.

Moreover, relevant ecological phenomena, e.g., re related to the reproduction of the species, or to their use of the habitat, often operate at different scales than the institutions in charge of the policies for fisheries management [60–62]. For example, it is difficult to address through international regulations phenomena that occurs at the global scale (e.g., ocean warming), because solutions must be provided at smaller scales, and based on transdisciplinary science and consensus of key affected stakeholders [63]. Therefore, although the legislations analyzed in this study presented a high degree of compliance with the principles of ecological and socio-economic sustainability, their efficiency could be lower than expected because mismatches between geographical scales could affect the institutional fit. In spite of the EU legislation tries to develop a common management of shared stocks, most of the species harvested by the European recreational fishers are not under these regulations [20]. In addition, the ignorance of basic biology and ecology of most of the species captured by European recreational fishers makes it impossible to identify the ideal scales of stock management, which in the last case must be carried out in a coordinated manner between the whole of the administrative scales involved. Thus, it is necessary to strength adaptive policies with public participation at local, regional and national levels to avoid undesired practices and outcomes, to increase the resilience long-term sustainability of EU MRF as complex SES [33,64,65].

## 5. Conclusions

The number of regulations on MRF that make up the legislation frameworks analyzed in this study could not be considered a proxy of the interest of the legislative institutions in response to demands from the public, because the UK was the country with the lower number of regulations but it shows the higher intensity of access to MRF [1]. The differences in the size of the legal frameworks are probably related to institutional inertias conditioned by the distribution of fishing competences among the different administrations involved in the management of MRF (many of them in the case of Spain). The legal frameworks are also conditioned by the differences in the type of access provided to the fishers, highly regulated in the case of Spain and Portugal [20,39], and almost open-access in the UK [38]. Moreover, the number of regulations is not related to the development of confluent public policies with the EAF principles. Thus, although Spain showed the highest number of regulations and obtained the highest IPLI, the EU obtained the second highest IPLI despite the lowest number of regulations on MRF. Moreover, the high number of regulations about MRF in Portugal and Spain generates confusion among fishers [20,39], and in practice could jeopardize the application of the intention of the regulators.

The adapted EFLA used in this research showed that the management of the European MRF follow the EAF principles, at least at the EU level and in Portugal, Spain and the United Kingdom. However, it would be good to reevaluate these principles at the lowest management levels and on larger spatial scales, e.g., including differences between the Atlantic and the Mediterranean, to assess potential institutional misfits derived from the eventual confluence of different spatial scales. In any case, it should be borne in mind that policies directed at small scales must be coordinated to have an effect at larger scales.

The overlapped distribution of the fish scales allows fishes to keep their skin healthy, even when they lose some of the scales. In a similar way, the different administrative levels involved in the EAF management of MRF provides some resilience to this complex SES because those aspects that are not regulated by a given administration can be regulated by another administrative level. However, the socio-economic component of the system showed in general a higher lack of coverage that at least should be further investigated. In this sense, the development of co-management initiatives and adaptive management could benefit the long-term sustainability of European MRF.

[3] Rules or laws established by organizations or communities to regulate themselves, as allowed by some higher authority, in general a legislature or some other government body.

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