# Analysing biodiversity records and conservation areas for freshwater fishes in Spain

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## Summary

The number of threatened freshwater fish species in Spain is among the highest recorded in Europe and includes a high percentage of endemic taxa. We investigated the distribution of Spanish freshwater fish to identify priority areas for conservation and assess the extent to which freshwater fish are included in the existing network of protected areas. We considered those threatened species recorded in the Spanish National inventories. From these data, several biodiversity indices were calculated and analysed. Our results reveal important discrepancies between the national and international assessments of conservation status. The current Spanish national catalogue requires updating to reconcile these inconsistencies. Several important areas for the conservation of freshwater fish lie outside protected areas. Our results encourage the establishment of protected areas specifically for freshwater environments. An extensive database of Spanish freshwater fish species is needed to redefine priority areas and to maintain freshwater biodiversity.

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## Introduction

Over 37% of European freshwater fishes are threatened, and about 17% of them have declining populations (Freyhof and Brooks, 2011). This is one of the highest threat levels of any major taxonomic group assessed to date in Europe. Unfortunately, for 76% of European species, there are insufficient data to define their population trends (Kottelat and Freyhof, 2007). Most threatened species are confined to specific areas in southern Europe within the Mediterranean region. This region of southern Europe is particularly rich in freshwater fishes and other taxa and has been recognised as a global “biodiversity hotspot” (Myers et al., 2000).

Seventy percent of freshwater species in the Mediterranean region are catalogued as threatened with extinction or are already extinct (Smith and Darwall, 2005). This is the highest percentage recorded anywhere in the world for any taxonomic group (Vié et al., 2009). This condition is related with a high degree of endemism and a long history of human impact in this area. Within the Mediterranean region, the Iberian Peninsula has long been subject to anthropogenic disturbance, leading to the poor conservation status of its ichthyofauna: 52% of species are threatened according to the Red List of the International Union for Conservation of the Nature (IUCN, 2013).

Despite local efforts over the past few decades to prevent the decline of some native fishes, such as the critically endangered Samaruc Valencia hispanica (Valenciennes, 1846) along the Levantine coast (Planelles, 1999), the status of most native species throughout the Iberian Peninsula remains bleak, demanding a re-evaluation of current freshwater conservation measures for the area (Maceda-Veiga, 2013).

The poor conservation status of Iberian freshwater fish species calls for the design and implementation of conservation plans. The first steps towards protecting the unique biodiversity of this region should be to appropriately designate and manage protected areas. These measures are of primary importance for protecting biodiversity in situ and the ecological processes that occur within ecosystems. Here, we use the distribution of Spanish freshwater fish to 1) detect priority conservation areas and 2) evaluate to which extent current reserve system cover freshwater fish species.


**Figure 1**. Outline of the principal hydrographical basins of Spain and its geographical location within Europe.

## Materials and Methods

In this study, we considered Spanish species recorded in the Atlas and Red Book of freshwater fishes of Spain (Doadrio, 2002) and the most recent national inventory (Doadrio et al., 2011). These books provide extensive information on the biodiversity of, threats to and conservation statuses of freshwater fishes in Spain. A taxonomic review of valid common and scientific names was carried out using the species lists; the scientific names used followed W. N. Eschmeyer's (2013) Catalog of Fishes and common names used followed Leunda et al. (2009).

We then consulted the following sources to identify the threatened species and their national and international conservation statuses: the International Union for Conservation of Nature (IUCN) Red List (global assessments; IUCN 2013), the European Habitats Directive 92/43/EEC and the Spanish National Catalogue of threatened species (Boletin Oficial del Estado, Real Decreto 139/2011), the latter of which lists wildlife species under special protection and species under a category of risk.

Information on species occurrences in Spain (Fig. 1) was obtained from the National Inventory of Biodiversity, which contains data collected since 1980 and gathered in 2008 on the distribution of mammals, birds, reptiles, amphibians and fishes. The database and grid (10x10 km cells) of inventory data were obtained from http://www.magrama.gob.es/es/biodiversidad/

temas/inventarios-nacionales/inventario-especies-terrestres/inventario-nacional-de-biodiversidad/inb_bbdd.aspx.

We calculated several indices of biodiversity quality using the inventory data: species richness, a rarity score, a vulnerability index and a biodiversity index. Species richness was measured as the total count of species within each grid cell. The native and non-native species richness was also calculated. The remaining indices were calculated following Abellán et al. (2005). The rarity score was calculated for all species in a grid cell by summing the inverse of all species' ranges and dividing by the species richness of the grid cell (Rey-Benayas and De la Montaña, 2003):

$$\text{Rarity score} = \sum_{i=1}^{S} (1/c_i)/S$$

where $c_i$ is the number of grid cells occupied by species *i* and S is the species richness of the grid cell. The Vulnerability Index was calculated using the conservation status of the species recorded in each grid cell. For each threat category, we assigned a score reflecting the species extinction risk. For the IUCN Red List categories, we assigned a value of 4 to Critically Endangered, 3 to Endangered, 2 to Vulnerable and 1 to Near Threatened. The vulnerability index was calculated as the sum of the vulnerability scores for each species present in a geographic area and divided by the species richness of that area:

$$\text{Vulnerability Index} = \sum_{i=1}^{S} v_i / S$$

where $v_i$ is the vulnerability score of species *i* and S is the species richness of the grid cell. Finally, the biodiversity index was calculated following Abellán et al. (2005), combining richness, rarity and vulnerability criteria, and defined as:

$$\text{Biodiversity Index} = \sum_{i=1}^{S} (1/c_i) v_i$$

where $c_i$ is the number of grid cells occupied by species *i* and $v_i$ is the vulnerability score of species *i*. Species richness is implicit in Σ.

The indices were calculated at the national level as well as for protected areas. We used ArcGis 10.0 (ESRI, 2011) to plot maps with indices for Spain.

The new information obtained was overlaid onto 10x10 km grids of Spanish peninsular territory. In addition, we acquired the geospatial data of watercourses and protected areas in Spain from the webpages of the Spanish Administration (Ministerio de Agricultura, Alimentación y Medio Ambiente, Government of Spain). Protected areas are under national and regional jurisdictions according to Spanish law (Boletin Oficial del Estado, Ley 42/2007); these include parks (national and natural), natural reserves, natural monuments, protected landscapes, the Natura 2000 network of protected areas and other protected natural areas.

To analyse the conservation status of Spanish rivers, indices of biodiversity quality were assigned to river sections partitioned into 10x10 km grids (Fig. 2b). These river stretches were then subdivided according to their protected status (protected or unprotected, Fig. 2c), obtaining finally the analysed river stretches. Geospatial analysis was conducted with ArcGis 10.0 (ESRI, 2011). To evaluate the extent to which river stretches of high conservation value were included in protected areas, we compared total river length (in km) within each index category between protected and unprotected areas using a chi-square test. This analysis was performed for each quality index or score (i.e., species richness, rarity score, vulnerability and biodiversity indexes).

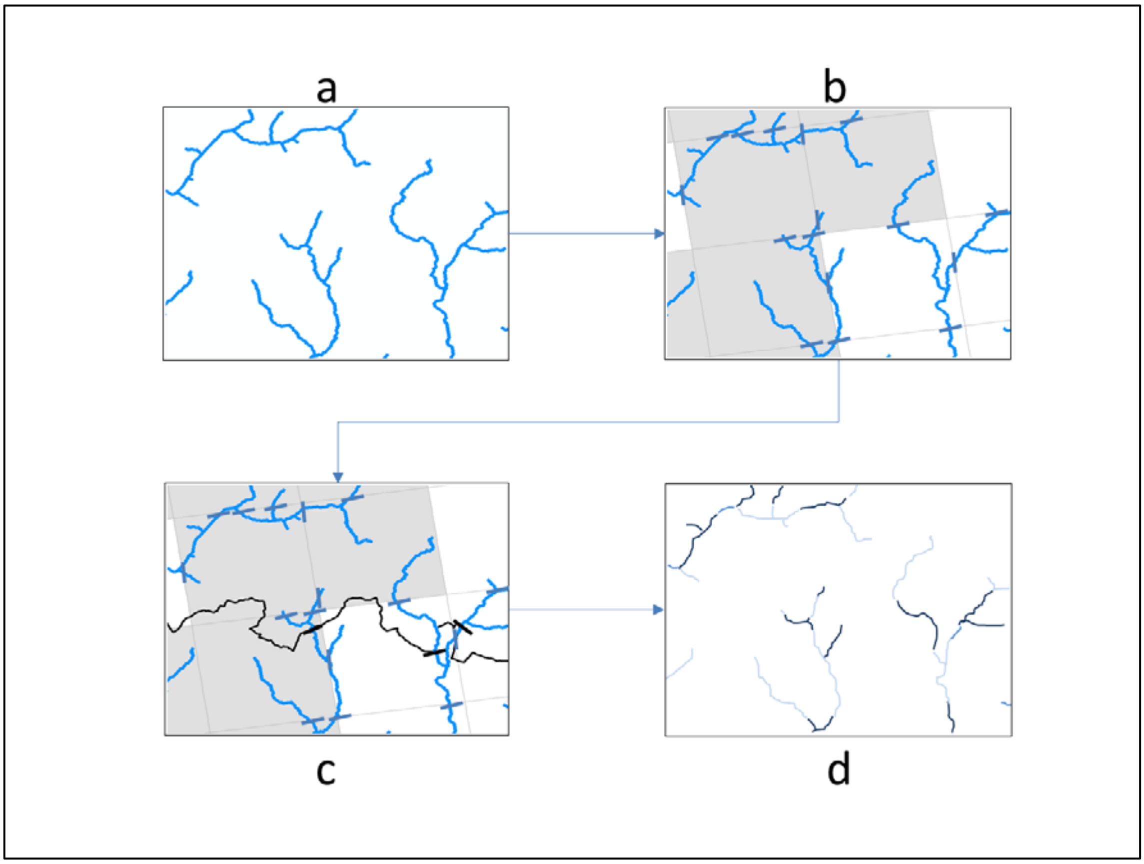


**Figure 2.** Methodological fragmentation model of rivers to assess its conservation status. Rivers sections are partitioned into 10x10 km grids (grey lines, b), and subsequently subdivided according to their protected or unprotected status (black line, c), obtaining final river stretches.

## Results

Based on the literature and updated database information, there are 81 species of freshwater fishes in Spain (Table 1), including anadromous and catadromous species (e.g. *Anguilla*, *Salmo*, *Alosa*) and endemic species present in coastal lagoons (e.g. *Aphanius*, *Valencia*), and the flounder *Platichthys flesus*, since in some Cantabrian rivers makes much of their life cycle in freshwater (Doadrio et al. 2011). Fifty-two species are native, and 29 are introduced. Among native species, 65% are endemic to the Iberian Peninsula.

We observed discrepancies between the IUCN Red List and the Spanish National Catalogue in species classified as threatened (Table 1). Some species listed as threatened in the Spanish normative also appeared in the IUCN Red List but were classified as either Least Concern or Near Threatened. In addition, the IUCN Red List classifies 27 freshwater fish species as threatened whereas the Spanish National Catalogue lists only 12. Therefore, two, six and 12 species classified by the IUCN as critically endangered, endangered and vulnerable, respectively, are not considered in the Spanish National Catalogue.

The National Inventory of Biodiversity included 16,380 records of freshwater fishes within the grid. From these data, indices of biodiversity quality were obtained for 3,849 cells and 12,285 fluvial stretches within them.

The native species richness map obtained for Spain showed that the Ebro (particularly the western region), Tagus and Júcar basins have the greatest number of grid cells with the highest species richness (Fig. 3a). Grid cells with the highest non-native species richness coincided with those of highest richness (Fig. 3b). The highest rarity scores were concentrated in Mediterranean areas: the Catalonian and Levantine Rivers and the Júcar basin (Fig. 4a). The vulnerability index map indicated that areas with high numbers of cells with high vulnerability scores included the same Levantine basins, as well as western Guadiana and the main Galician basins (northwestern region of the Iberian Peninsula, Fig. 4b).

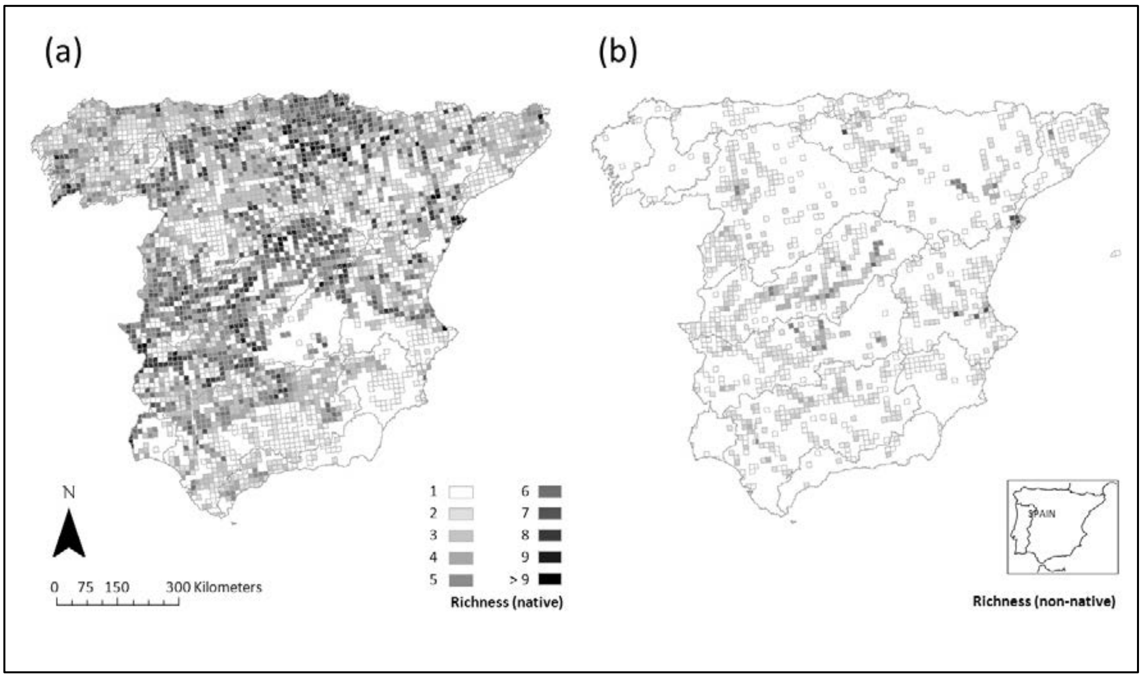


**Figure 3.** Native (a) and non-native (b) freshwater fish species richness in Spain calculated from National Inventory of Biodiversity occurrence data, distributed over 10x10 km grid cells (defined by UTM coordinates).

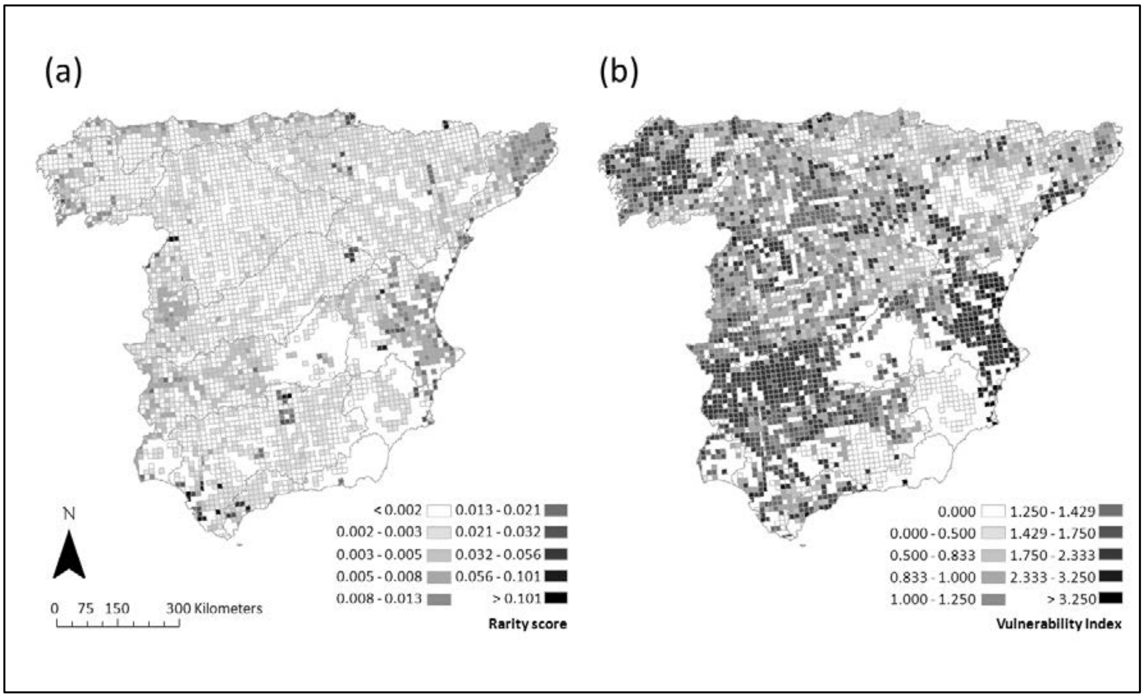


**Figure 4.** Rarity scores (a) and vulnerability index values (b) of native freshwater fish in Spain obtained from National Inventory of Biodiversity occurrence data, distributed over 10x10 km grid cells (defined by UTM coordinates).

Grid cells with the highest biodiversity index values were concentrated along the Mediterranean coast, with some located in the southern Iberian Peninsula and other areas scattered throughout the Spanish territory (Fig. 5).

The analysis of kilometres of river stretches within and outside protected areas showed that 14.6% of rivers fell within protected areas (natural reserves and national parks, Table 2). The proportion of river stretches included in protected areas increased with increasing biodiversity index (62.6% for the highest category; $\chi^2$=53.2, df=4, P<0.001) and rarity score values (42.9% for the highest category; $\chi^2$=42.5, df=4, P<0.001) but was not significantly different among categories of vulnerability index ($\chi^2$=19.4, df=4, P=0.065) or species richness ($\chi^2$=7.4, df=4, P=0.114). Among officially protected areas, parks had the greatest total river length and the highest biodiversity values in protected areas (Table 2).

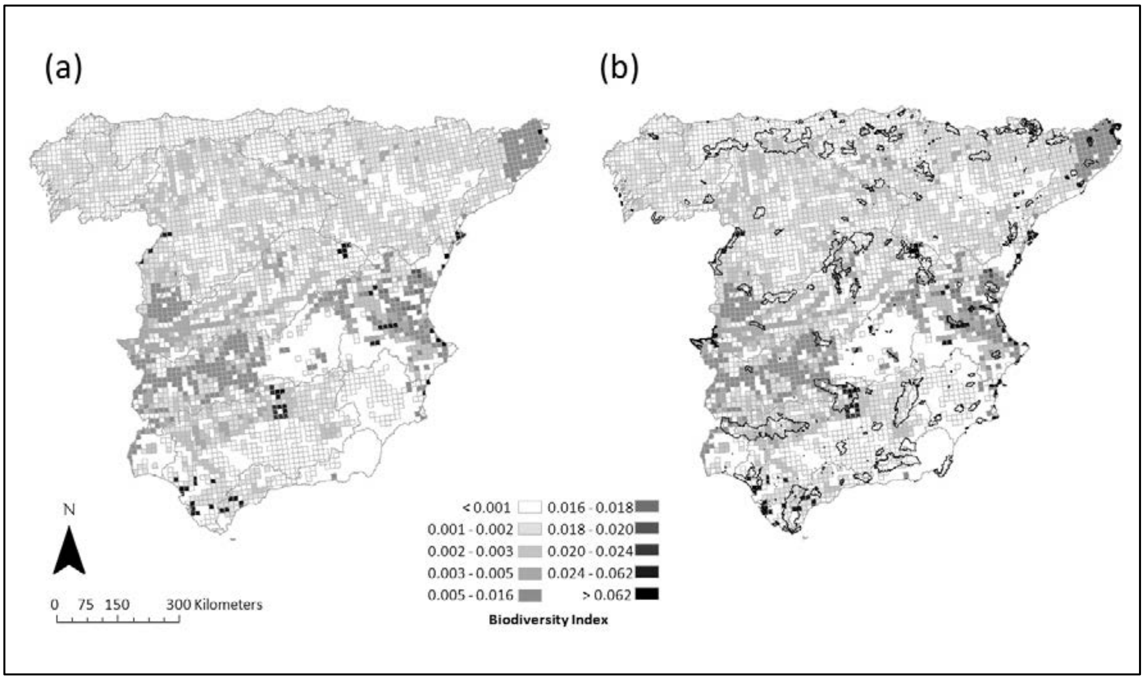


**Figure 5.** Biodiversity index values of native freshwater fish in Spain, excluding (a) and including (b) parks and natural reserves, distributed over 10x10 km grid cells (defined by UTM coordinates). Values calculated from National Inventory of Biodiversity occurrence data.

## Discussion

Spain has among the highest recorded diversity of threatened freshwater fish in Europe (Freyhof and Brooks, 2011), including many endemic species (Doadrio, 2011; Maceda-Veiga 2013). Unfortunately, introductions of exotic fish species have increased in recent decades (Leunda 2010): among the 29 non-native species in Spain, ten were introduced within the last twenty years (Elvira and Almodóvar, 2001; Caiola and De Sostoa 2002; Doadrio, 2002; Franch et al., 2008).

Substantial differences exist between the IUCN Red List and the Spanish Catalogue of Threatened Species in the classification of threatened species. Some differences reflect certain species having a restricted Spanish distribution within an otherwise broader distribution; for example, the anadromous lampreys *Petromyzon marinus* and *Lampetra planeri* and the freshwater blenny *Salaria fluviatilis*. More surprising, however, are species endemic to Spain and classified as endangered or critically endangered by the IUCN Red List but not considered threatened according to the national list. The most striking examples include the European eel *Anguilla anguilla*, which is in clear decline in all populations (e.g., Dorrow et al., 2010), and the endemic Oretanian arched-mouth nase *Iberochondrostoma oretanum* (Doadrio and Carmona 2003). Both species are categorised by the IUCN as critically endangered but are absent from the Spanish legislation. The Spanish National Catalogue requires updating to reconcile these incongruences, and future research is needed to accurately assess the conservation status of Spanish freshwater fish.

Average species richness at the grid cell scale ranged between one and 14. These data should be considered in light of the differential sampling effort, as some areas were less studied or prospected than others. However, although there are areas insufficiently sampled or without data (there are visible gaps in the maps), occurrences are the sum of many samplings in a long period, and representativeness of included occurrences in the cell grids are consistent. Interestingly and unfortunately, the areas of highest native species richness coincide with those of highest non-native richness, presenting concern for managers and administrations. Invasive species affect biodiversity in several ways. Competition, predation and transmission of diseases between alien and native species can pose a major threat to native species (Leunda 2010). For example, in Spain, the introduction of northern pike *Esox lucius* Linnaeus 1758 is responsible for the local extinction of species assemblages (Elvira et al., 1996). In the Ebro delta (Catalonia, NE Spain), aquaculture research centres and ornamental aquaculture facilities have been responsible for the introduction of several exotic species (e.g., Mummichog *Fundulus heteroclitus*, Oriental Weather loach *Misgurnus anguillicaudatus* and Topmouth gudgeon *Pseudorasvora parva*) (Maceda-Veiga, 2013). The Ebro delta is a wetland area of national and international conservation importance (Mañosa et al. 2001) and yields the highest values of freshwater native species richness and the biodiversity index. The eradication of introduced species should be an objective to achieve in the future for the proper management of this and other areas with similar problems, such as the main waterways of the Tagus basin (Fig. 4). This management proposal should be taken with caution, considering the difficulty and cost of carrying out.

The greatest threats to freshwater fishes in Spain are 1) the continuous destruction and alteration of habitat due to natural system modification, agriculture expansion and agricultural intensification and 2) invasive species (Maceda-Veiga, 2013). Areas in this study with the highest values of the various indices of biodiversity quality (i.e., basins of the Mediterranean coast) are particularly threatened with human impact due to excessive urbanisation and, in some cases, uncontrolled water exploitation. For example, one of the main impacts of agricultural intensification on freshwater ecosystems may be eutrophication, which increases turbidity and causes shifts in community composition (Camargo and Alonso, 2006). Another threat to freshwater ecosystems is the construction of dams, which alters water flow patterns and the physical and chemical characteristics of freshwater rivers and lakes. Freshwater fishes are severely affected by changes in river flow as a result of dam construction (e.g., Miranda et al. 2012); they are also strongly affected by invasive species (Clavero et al., 2013). Dams are abundant in the Iberian Peninsula, particularly within Mediterranean basins. If construction of new dams continues, species that depend on larger rivers and streams with a natural flow pattern will be at increasing risk of extinction (Clavero et al., 2004; Freyhof and Brooks, 2011).

The indices of biodiversity identify certain areas of concern regarding the conservation of freshwater fish species. These data can inform stakeholders and decision makers, which should take into account the limitation of scoring criteria and, finally, the cost-effectiveness of manage measures. Anyway, although the biodiversity indices identify differences between protected and unprotected river stretches, the protection afforded by protected areas is insufficient. Although 62% of river stretches having the highest biodiversity index values and 43% of highest rarity scores lie within protected areas, almost 90% of river stretches with the highest vulnerability index values fall within unprotected regions (Table 2). More effort should be devoted to avoid the extinction of highly threatened, poorly protected taxa as some species of freshwater fish (Clark and May; 2002; Pino-del-Carpio et al. 2011). Many protected areas were not established to protect fish (Suski and Cooke, 2006). The establishment of isolated protected areas alone is not enough to protect freshwater fishes, as impacts upstream or downstream must also be considered (Filipe et al., 2004). In fact, terrestrial protected areas often include only part of a river's catchment or are delineated by rivers (Chessman 2013). Along with previous studies

(Filipe et al., 2004; Suski and Cooke, 2006; Abell et al. 2007), our results encourage the design of protected areas specifically for freshwater environments.

Finally, the occurrence data analysed in this study were compiled by the national administration until 2008 and reflect the knowledge and taxonomy available at the time of the last national survey (Doadrio et al., 2011). However, the occurrence data are imprecise (obtained at a 10x10 km scale), and some areas were poorly sampled. The use of 10x10 km grid cells to attribute indices values to river stretches should be considered with caution. Some cells might fall within two different catchments and indices values would be spuriously assessed to different rivers. However, these cases are generally in the headwaters of catchments, where it is possible that a catchment is from less that 10 km of other different catchment. These headwaters are generally poor in biodiversity and threatened species are not present in these places.

Although the present national compilation of the distribution of Iberian freshwater fishes is a deserving effort, an extensive database of Spanish freshwater fish occurrences is necessary to redefine priority areas for freshwater fishes and, more generally, for freshwater biodiversity. Research is needed to accurately assess the conservation status of threatened freshwater fishes in Spain.

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**Table 1**: List of registered Spanish freshwater fish species, their zoogeographic origin and their threat categories according to the IUCN Red List, the European Habitats Directive (92/43/CEE) and the Spanish National Catalogue. Categories are Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Lower Risk/Least Concern (LR/LC) and Least Concern (LC).

| Scientific name | Origin | IUCN | 92/43/CEE | Spanish National Catalogue |
|---|---|---|---|---|
| Family Petromyzontidae | | | | |
| *Lampetra planeri* (Bloch, 1784) | Native | LC | Annex II | VU |
| *Petromyzon marinus* Linnaeus, 1758 | Native | LC | Annex II | EN |
| Family Acipenseridae | | | | |
| *Acipenser baerii* Brandt 1869 | Introduced | EN A2bcd+4bcd | | |
| *Acipenser sturio* Linnaeus 1758 | Native | CR A2cde; B2ab(ii,iii,v) | Annex II Annex IV | EN |
| Family Cottidae | | | | |
| *Cottus aturi* Freyhof, Kottelat y Nolte, 2005 | Native | LC | Annex II | EN |
| *Cottus hispaniolensis* Bacescu-Mester, 1964 | Native | LC | Annex II | EN |
| Family Clupeidae | | | | |
| *Alosa alosa* (Linnaeus, 1758) | Native | LC | Annex II | |
| *Alosa fallax* (Lacépède, 1803) | Native | LC | Annex II | |
| Family Anguillidae | | | | |
| *Anguilla anguilla* Linnaeus, 1758 | Native | CR A2bd+4bd | | |
| Family Atherinidae | | | | |
| *Atherina boyeri* Risso, 1810 | Native | LC | | |
| Family Salmonidae | | | | |
| *Salmo salar* Linnaeus, 1758 | Native | LR/LC | Annex II | |
| *Salmo trutta* Linnaeus, 1758 | Native | LC | | |
| *Salvelinus fontinalis* (Mitchill 1814) | Introduced | | | |
| *Hucho hucho* (Linnaeus, 1758) | Introduced | EN B2ab(ii,iii) | | |
| *Oncorhynchus kisutch* (Walbaum 1792) | Introduced | | | |
| *Oncorhynchus mykiss* (Walbaum, 1792) | Introduced | | | |
| Family Cyprinidae | | | | |
| *Achondrostoma arcasii* (Steindachner, 1866) | Endemic | VU A3ce | Annex II | listed |
| *Achondrostoma salmantinum* Doadrio y Elvira, 2007 | Endemic | EN B1ab(ii,v)+2ab(ii,v) | | |
| *Alburnus alburnus* (Linnaeus, 1758) | Introduced | LC | | |
| *Anaecypris hispanica* (Steindachner, 1866) | Endemic | EN A2ace | Annex II Annex IV | EN |
| *Barbus haasi* Mertens, 1925 | Endemic | VU A2ce+3ce | | |
| *Barbus meridionalis* Risso, 1827 | Native | NT | Annex II | |
| *Blicca bjoerkna* (Linnaeus 1758) | Introduced | LC | | |
| *Carassius auratus* (Linnaeus, 1758) | Introduced | LC | | |
| *Cyprinus carpio* Linnaeus, 1758 | Introduced | VU A2ce | | |
| *Gobio lozanoi* Doadrio y Madeira, 2004 | Native | LC | | |
| *Iberochondrostoma lemmingii* (Steindachner, 1866) | Endemic | VU A2ace+3ce | Annex II | |
| *Iberochondrostoma oretanum* (Doadrio y Carmona, 2003) | Endemic | CR A2ace; B2ab(ii,iii) | | |
| *Luciobarbus bocagei* (Steindachner, 1864) | Endemic | LC | | |
| *Luciobarbus comizo* (Steindachner, 1864) | Endemic | VU A2ce | Annex II | |
| *Luciobarbus graellsii* (Steindachner, 1866) | Endemic | LC | | |
| *Luciobarbus guiraonis* (Steindachner, 1866) | Endemic | VU A3ce | | |
| *Luciobarbus microcephalus* (Almaça, 1967) | Endemic | VU A2ce+3ce | | |
| *Luciobarbus sclateri* (Günther, 1868) | Endemic | LC | | |
| *Parachondrostoma arrigonis* (Steindachner, 1866) | Endemic | CR A2ace; B2ab(i,ii,iii,iv,v) | | EN |

| | | | | |
|---|---|---|---|---|
| *Parachondrostoma miegii* (Steindachner, 1866) | Endemic | LC | | |
| *Parachondrostoma turiense* (Elvira, 1987) | Endemic | EN B2ab(i,iii,v) | | |
| *Phoxinus bigerri* Kottelat, 2007 | Endemic | LC | | |
| *Pseudochondrostoma duriense* (Coelho, 1985) | Endemic | VU A3ce | Annex II | |
| *Pseudochondrostoma polylepis* (Steindachner, 1864) | Endemic | LC | | |
| *Pseudochondrostoma willkommii* (Steindachner, 1866) | Endemic | VU A3ce+4ce | Annex II | |
| *Pseudorasbora parva* (Temminck & Schlegel 1846) | Introduced | LC | | |
| *Rutilus rutilus* (Linnaeus, 1758) | Introduced | LC | | |
| *Scardinius erythrophthalmus* (Linnaeus, 1758) | Introduced | LC | | |
| *Squalius alburnoides* (Steindachner, 1866) | Endemic | VU A3ce | Annex II | |
| *Squalius carolitertii* (Doadrio, 1987) | Endemic | LC | | |
| *Squalius castellanus* Doadrio, Perea y Alonso, 2007 | Endemic | EN B1ab(iii,v) | | |
| *Squalius laietanus* Doadrio, Kottelat y Sostoa, 2007 | Endemic | LC | | |
| *Squalius malacitanus* Doadrio y Carmona, 2006 | Endemic | EN B1ab(ii,iii,v)+2ab(ii,iii,v) | | |
| *Squalius palaciosi* (Doadrio, 1980) | Endemic | CR B1ab(ii,iii)+2ab(ii,iii) | Annex II | EN |
| *Squalius pyrenaicus* (Günther,1868) | Endemic | | | |
| *Squalius valentinus* Doadrio y Carmona, 2006 | Endemic | VU B1ab(ii,iii,v) | | |
| *Tinca tinca* (Linnaeus, 1758) | Introduced | LC | | |
| Family Cobitidae | | | | |
| *Cobitis bilineata* Canestrini 1865 | Introduced | LC | | |
| *Cobitis calderoni* Bacescu, 1962 | Endemic | EN A2ace+3ce | | |
| *Cobitis vettonica* Doadrio y Perdices 1997 | Endemic | EN B1ab(ii,iii,v)+2ab(ii,iii,v) | | |
| *Cobitis paludica* (De Buen, 1929) | Endemic | VU A2ce+3ce | | |
| *Misgurnus anguillicaudatus* (Cantor 1842) | Introduced | LC | | |
| Family Balitoridae | | | | |
| *Barbatula barbatula* (Linnaeus, 1758) | Introduced | LC | | |
| *Barbatula quignardi* (Bacescu-Mester, 1967) | Endemic | LC | | |
| Family Gasterosteidae | | | | |
| *Gasterosteus aculeatus* Linnaeus, 1758 | Native | LC | | |
| Family Cyprinodontidae | | | | |
| *Aphanius baeticus* Doadrio, Carmona y Fernández-Delgado, 2006 | Endemic | EN A2ce | | EN |
| *Aphanius fasciatus* (Valenciennes 1821) | Introduced | LC | | |
| *Aphanius iberus* (Valenciennes, 1846) | Endemic | EN A2ce | Annex II | EN |
| Family Valenciidae | | | | |
| *Valencia hispanica* (Valenciennes, 1846) | Endemic | CR A2ace | Annex II Annex IV | EN |
| Family Blenniidae | | | | |
| *Salaria fluviatilis* (Asso, 1801) | Native | LC | | VU |
| Family Gobiidae | | | | |
| *Pomatoschistus microps* (Kroyer, 1838) | Native | LC | | |
| Family Mugilidae | | | | |
| *Chelon labrosus* (Risso, 1827) | Native | LC | | |
| Family Pleuronectidae | | | | |
| *Platichthys flesus* (Linnaeus, 1758) | Native | LC | | |
| Family Ictaluridae | | | | |
| *Ameiurus melas* (Rafinesque, 1980) | Introduced | LC | | |
| *Ictalurus punctatus* (Rafinesque 1818) | Introduced | LC | | |
| Family Siluridae | | | | |
| *Silurus glanis* Linnaeus, 1758 | Introduced | LC | | |
| Family Esocidae | | | | |

| | | |
|---|---|---|
| *Esox lucius* Linnaeus, 1758 | Introduced | LC |
| Family Fundulidae | | |
| *Fundulus heteroclitus* (Linnaeus 1766) | Introduced | LC |
| Family Poeciliidae | | |
| *Gambusia holbrooki* (Girard, 1859) | Introduced | LC |
| *Poecilia reticulata* Peters 1859 | Introduced | |
| Family Centrarchidae | | |
| *Lepomis gibbosus* (Linnaeus, 1758) | Introduced | LC |
| *Micropterus salmoides* (Lacépède, 1802) | Introduced | LC |
| Family Percidae | | |
| *Perca fluviatilis* Linnaeus 1758 | Introduced | LC |
| *Sander lucioperca* (Linnaeus, 1758) | Introduced | LC |
| Family Cichlidae | | |
| *Australoheros facetus* (Jenyns 1842) | Introduced | |

**Table 2**: Kilometres of river stretches included in unprotected (Km NPA) and protected areas (Km PA), grouped by index category and type of protected area: parks (PK) or natural reserve (NR).

| | **Km NPA** | **Km PA** | **% PA** | **PK** | **NR** |
|---|---|---|---|---|---|
| Total | 49952 | 9955 | 14.6 | 9067 | 888 |
| Biodiversity Index | | | | | |
| 1 (<0.002) | 30069 | 5389 | 13.2 | 4742 | 647 |
| 2 (0.002-0.004) | 13723 | 2977 | 16.1 | 2843 | 134 |
| 3 (0.005-0.014) | 5138 | 754 | 11.2 | 718 | 36 |
| 4 (0.015-0.033) | 768 | 318 | 25.1 | 247 | 71 |
| 5 (>0.033) | 254 | 518 | 62.6 | 518 | - |
| Vulnerability Index | | | | | |
| 1 (<0.5) | 8832 | 2331 | 18.2 | 2013 | 318 |
| 2 (0.5-0.9) | 10194 | 1940 | 14.1 | 1672 | 268 |
| 3 (1-1.5) | 18074 | 3809 | 15.7 | 3537 | 272 |
| 4 (1.6-2.5) | 12328 | 1804 | 10.8 | 1779 | 26 |
| 5 (>2.5) | 524 | 71 | 10.2 | 65 | 5 |
| Rarity score | | | | | |
| 1 (<0.003) | 37342 | 7463 | 14.9 | 6893 | 571 |
| 2 (0.003-0.008) | 10504 | 1517 | 10.5 | 1271 | 246 |
| 3 (0.009-0.021) | 1639 | 445 | 16.9 | 375 | 70 |
| 4 (0.022-0.055) | 314 | 393 | 49.2 | 393 | - |
| 5 (>0.055) | 154 | 137 | 42.9 | 135 | 2 |
| Richness | | | | | |
| 1 (<3) | 14549 | 2585 | 13.0 | 2395 | 190 |
| 2 (3-4) | 16245 | 3050 | 13.7 | 2710 | 340 |
| 3 (5-6) | 12334 | 2947 | 17.4 | 2764 | 183 |
| 4 (7-8) | 5980 | 1154 | 14.7 | 1009 | 144 |
| 5 (>8) | 844 | 220 | 17.3 | 188 | 32 |