Habitat recovery and related conservation efforts: 4

Catarina S. Mateus, Laurent Beaulaton, J. Bochechas, S. Bruxelas, F. Cobo, A. Franco, D.J. Nachón, B.R. Quintella, Camille Rosa, Thibault Rougier, et al.

4 HABITAT RECOVERY AND RELATED CONSERVATION EFFORTS

Mateus C.S., Beaulaton L., Bochechas J., Bruxelas S., Cobo F., Franco A., Nachón D.J., Quintella B.R., Rosa C., Rougier T., Silva S., Stratoudakis Y. and Telhado A.

4.1 INTRODUCTION

In the last decades there have been great advances in the knowledge and awareness of the threats to and requirements of migratory species, like lampreys and shads. In several countries a number of sites important for the conservation of these species have been identified, several habitat recovery actions were conducted, and there is a growing effort to involve and inform the general public on necessary conservation actions.

The main threats to these species are similar across river basins and across countries, even though there are some cases where a certain impact is more critical in a given basin or country. In general, impacts affecting the freshwater phase of the life cycle (larval development, migration and spawning) are critical. Pollution, habitat destruction, dams and other engineering works, exploitation by humans and climate change have been identified as the main threats affecting lampreys (reviewed in Maitland *et al.* 2015) and shads (Baglinière *et al.* 2003). Anthropogenic pressures have led to a drastic restriction and fragmentation of the distribution area of migratory species and to the placement of these species on the red list of threatened species.

Most lamprey and shad species are evaluated at a global scale by the IUCN red list of threatened species (www.iucnredlist.org), but at a national level this is not consistently done between countries. Below we present the conservation status (IUCN categories) of lampreys (sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis* and brook lamprey *Lampetra planeri*) in 2012 in the countries where such information exists (Table 4.1; from Mateus *et al*. 2012), and the conservation status of shads (allis shad *Alosa alosa* and twaite shad *Alosa fallax*) in 2003 (Table 4.2 to Table 4.4; from Aprahamian *et al*. 2003 and Baglinière *et al*. 2003). For lampreys, the information on the conservation status, even though rather complete, sometimes does not follow the IUCN categories, and some countries tend to adopt alternative categories that have limited comparability due to the lack of sub-criteria and standardization across countries or regions.

As for the legislation, there are a number of international directives protecting these species. In Europe the two important pieces of legislation are the Bern Convention and the Habitats Directive. The requirement for member states to establish Special Areas of Conservation (SACs) is the most important practical element affecting species in the Habitats Directive. In addition to protection at the EU level, some species are also given protection at a more local level in some countries (reviewed in Maitland *et al.* 2015). In addition, these species are protected by the following legislation: OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic), HELCOM (Baltic Marine

Environment Protection Commission), Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals) and UNCLOS (United Nations Convention on the Law of the Sea).

Table 4.1. *Petromyzon marinus* and *Lampetra* spp. 2001 International Union for Conservation of Nature (IUCN) Red List categories for countries where information exists across their natural range. In Italy, *P. marinus* and *L. fluviatilis* are often classified as Regionally Extinct, but these species still reproduce at least in the River Magra (Bianco and Delmastro 2011). In Slovenia, *P. marinus* is present in the Adriatic river basin (Povž 2002). In Lithuania, *L. fluviatilis* and *L. planeri* are common, not being included in the Red data book (T. Virbickas and R. Repecka personal communication). RE: Regionally Extinct; CR: Critically Endangered; EN: Endangered; VU: Vulnerable; n/t: not threatened; LC: Least Concern; DD: Data Deficient; NE: Not Evaluated. Other categories are R: Rare; NT: Near Threatened; LR: Lower Risk; NA: not applicable; X: species occurrence not confirmed; –: no data available/not included in the Red data book (from Mateus *et al.* 2012). Updated conservation data in Ireland classifies sea lamprey as *Near Threatened* [A2c, B1ab(iii)], and river and brook lampreys as *Least Concern* (King *et al.* 2011).

Country	*P. marinus*		*L. fluviatilis*		*L. planeri*	
	IUCN	Source	IUCN	Source	IUCN	Source
Russia	EN	Russian Academy of Sciences (2001)	–	–	–	–
Finland	NA[a]	Rassi et al. (2010)	NT	Rassi et al. (2010), Urho & Lehtonen (2008)	LC	Kaukoranta et al. (2000)
Norway	LC[b]	Kålås et al. (2010)	LC[b]	Kålås et al. (2010)	LC[b]	Kålås et al. (2010)
Sweden	NT	Gärdenfors (2010)	LC	Gärdenfors (2010)	LC	Gärdenfors (2010)
Estonia	NE[c]	Lilleleht et al. (2008)	LC	Lilleleht et al. (2008)	DD	Lilleleht et al. (2008)
Ireland	VU	Maitland (2004)	LR	Maitland (2004)	LR	Maitland (2004)
Great Britain	VU	Maitland (2000)	VU	Maitland (2000)	VU	Maitland (2000)
Denmark	VU	Carl et al. (2004)	DD[d]	Carl et al. (2004)	LC	Carl et al. (2004)
Lithuania	EN[e]	Rašomavičius (2007)	–	–	–	–
Poland	EN	Głowaciński et al. (2002)	VU	Głowaciński et al. (2002)	VU	Witkowski et al. (2003)
Belgium - Flanders	RE	Kestemont (2010)	R	Kestemont (2010)	VU	Kestemont (2010)
Belgium - Wallonia	RE[f]	Philippart (2007), Kestemont (2010)	RE[f]	Philippart (2007), Kestemont (2010)	VU	Philippart (2007), Kestemont (2010)
Germany	n/t	Freyhof (2002)	n/t	Freyhof (2002)	n/t	Freyhof (2002)
Czech Republic	RE	Lusk et al. (2004)	RE	Lusk et al. (2004)	EN	Witkowski et al. (2003), Lusk et al. (2004)
Ukraine	X	X	–	–	LC	Witkowski et al. (2003)
Slovakia	–	–	X	X	CR	Witkowski et al. (2003)
Switzerland	–	–	RE	Kirchhofer et al. (2007)	EN	Kirchhofer et al. (2007)
France	NT	IUCN France et al. (2010)	VU	IUCN France et al. (2010)	LC	IUCN France et al. (2010)
Slovenia	EN[g]	Povž (2011)	X	X	–	–
Croatia	DD	Mrakovčič et al. (2007)	X	X	NT	Mrakovčič et al. (2007)
Italy	–	–	–	–	NT	Bianco et al. (2011)
Spain	VU[h]	Doadrio (2001)	RE	Doadrio (2001)	CR[i]	Doadrio (2001)
Portugal	VU	Cabral et al. (2005)	CR	Cabral et al. (2005)	CR	Cabral et al. (2005)

[a]Recorded, but only occasionally and/or not reproducing; [b]Little information available on the distribution and status in Norway. It is assumed that <1 % of the total European stock occurs in Norway (E. Thorstad pers. comm.); [c]Rare in Estonian waters. No reliable data available about the reproduction of sea lamprey in Estonia (Saat et al. 2002); [d]Species is rare and may be threatened, but data are missing from several of the suspected habitats; therefore categorised as DD; [e]Population abundance is very low, has been officially recorded in Lithuania a few times (T. Virbickas & R. Repecka pers. comm.); [f]Likely to return (Philippart 2007); [g]In Slovenia it is very rare and is restricted to the Pirano Bay and inflowing rivers in the North Adriatic Sea (Povž 2011); [h]Endangered according to decree no. 139/2011 (BOE 2011), but only for populations from the Rivers Guadiana, Guadalquivir and Ebro and those from the southern basins; [i]Vulnerable according to decree no. 139/2011 (BOE 2011)

Table 4.2. Conservation status of allis shad (*Alosa alosa*) by country in the Eastern Atlantic Ocean and Western Mediterranean Sea according to IUCN (1994) criteria (from Baglinière *et al.* 2003). Updated conservation data in Ireland classifies allis shad as *Data Deficient* (King *et al.* 2011).

Conservation status	Criteria	Countries
Extinct	There is no reasonable doubt that the last individual has died.	Belgium, Luxembourg, Sweden
Critically endangered	Species is facing an extremely high risk of extinction in the wild in the immediate future.	Denmark, Great Britain, Ireland, Spain (Mediterranean Sea)
Endangered	Species is not critically endangered but is facing an extreme risk of extinction in the wild in the near future.	Germany, The Netherlands, Portugal, Spain (Atlantic Ocean)
Vulnerable	Species is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future.	France

Table 4.3. Conservation status of twaite shad (*Alosa fallax*) by country according to IUCN (1994) criteria (from Aprahamian *et al.* 2003).

Conservation status	IUCN (1994) criteria	Countries
Extinct	When there is no reasonable doubt that the last individual has died	Belgium, Luxembourg, Sweden, Netherlands
Critically endangered	When it is facing an extremely high risk of extinction in the wild in the immediate future	Denmark
Endangered	When it is not critically endangered but is facing an extremely high risk of extinction in the wild in the near future	Germany, Lithuania, Poland
Vulnerable	When it is not critically endangered or endangered but is facing a high risk of extinction in the wild in the medium-term future	Ireland, France, Portugal, Spain, UK
Not evaluated	When it has not been assessed against the criteria	Finland
Data deficient	When there is inadequate information to make a direct [or] indirect, assessment of its risk of extinction based on its distribution and/or population status	Sweden
Absent from red data book or equivalent		Austria

4.2 HABITAT DIRECTIVE IMPLEMENTATION

The EU Habitats Directive (1992) is the main piece of legislation protecting wildlife across Europe. It is built around two pillars: the Natura 2000 network of protected sites, and the strict system of species protection. At present, all the 28 countries in Europe that are members of the EU are co-signers to the EU Habitats Directive.

4.2.1 Portugal

For *Lampetra* sp. in Portugal, a National Conservation Plan was implemented that included a comprehensive sampling survey to identify presence or absence of ammocoetes throughout Portuguese watersheds (Figure 4.1). The main objective of this plan was to gather the necessary information to properly designate SACs for this genus in Portugal.

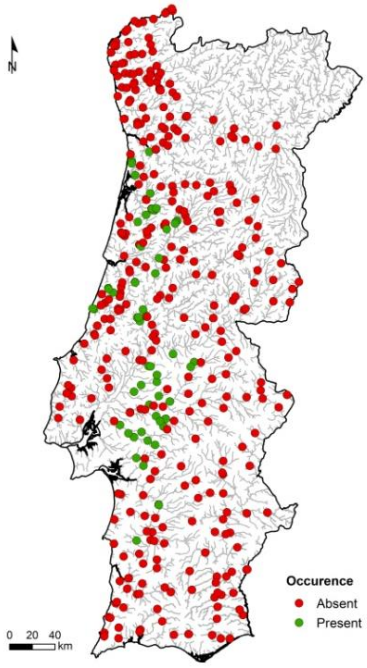


Figure 4.1. Distribution of the sampling sites (N = 401) in Portugal.

The presence/absence information was statistically analyzed, together with several environmental predictors selected a priori, generating a predictive model that explains the distribution (i.e., probability of occurrence) of *Lampetra* sp. in Portugal (Ferreira *et al.* 2013). Using the distribution model output, a map with the probability of occurrence of *Lampetra* sp. in Portugal was generated and stretches of rivers were delimited with different conservation priorities (Figure 4.2). Rivers classified with the highest level of conservation priority were considered to be proposed as SACs, under the Natura 2000 Networking Programme. Those are the following: Inha river (Douro basin); Mangas stream (Esmoriz

basin); Negro river, Vouga river, Águeda- Alfusqueiro rivers, Cértima river, Levira river (Vouga basin); Mortágua stream, Criz river, Ançã stream, Ceira river, Corvo stream, Anços river (Mondego basin); Leça stream (Lis basin); S. Pedro stream (Small independent streams of Oeste); Nabão river, Torto river, Ulme stream, Muge stream, Longomel stream, Erra stream, Sorraia river, Divôr river, Almansor river (Tejo basin); Marateca stream, S. Martinho stream, Barranco Brejo Largo stream, S. Domingos stream (Sado basin) (Ferreira *et al.* 2013).

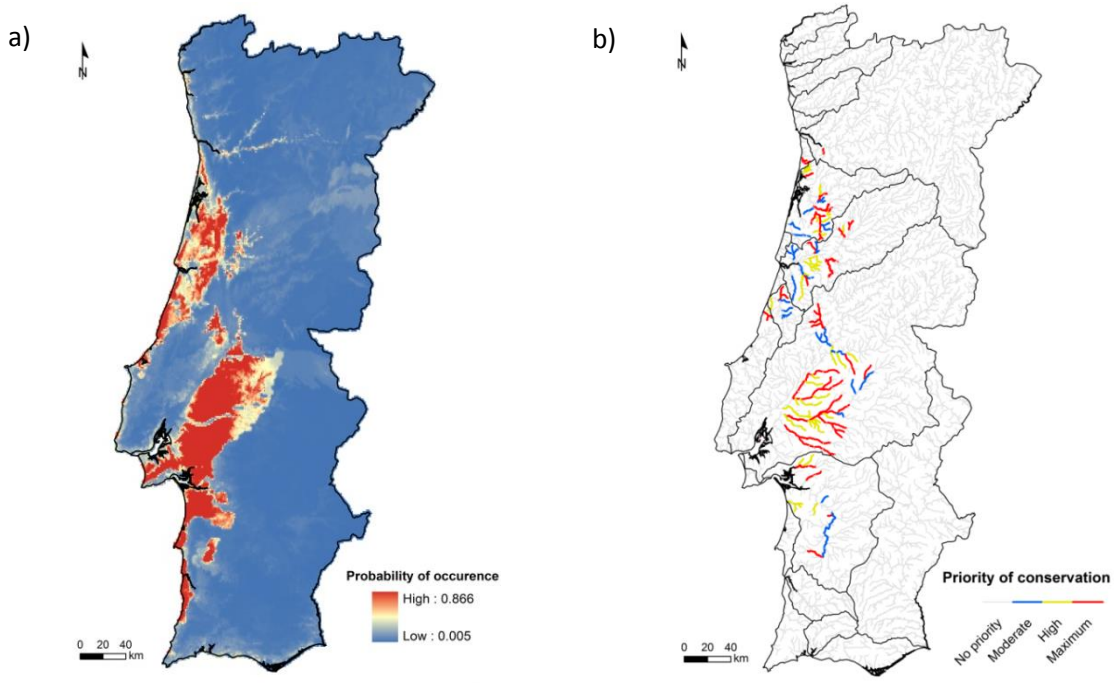


Figure 4.2. Definition of areas to be proposed as SACs for *Lampetra* sp. in Portugal. a) distribution of *Lampetra* sp. probability of occurrence in Portugal. Data predicted with a 1 km2 spatial resolution from a BRT model, using the species presence/absence data as the response variable and geomorphological and climatic environmental variables as predictors, b) map of priority of conservation of *Lampetra* sp. in Portugal, where water stretches included in the highest priority conservation level were set to be proposed as SAC under the European Natura 2000 ecological network of protected areas (from Ferreira *et al.* 2013).

So far Portugal has designated 12 Sites of Community Importance (SCI) under the Habitats Directive, which include in their objectives the protection of the following species of lampreys and shads, and their habitats (Table 4.4).

Concerning *A. alosa* the following map (Figure 4.3,Table 4.5) represents the geographic distribution of the species (green squares) and the SCI (yellow) which include in their objectives the protection of *A. alosa*.

Table 4.4. Species of lampreys and shads included in the Habitats Directive in Portugal.

Species code	Species name
1102	*Alosa alosa*
1103	*Alosa fallax*
1095	*Petromyzon marinus*
1099	*Lampetra fluviatilis*
1096	*Lampetra planeri*

Table 4.5. Natura 2000 sites designated under the Habitats Directive in Portugal for *A. alosa*.

Species	SITE CODE	SITE NAME	Relevance
Alosa alosa	PTCON0009	Estuário do Tejo	Relevant
Alosa alosa	PTCON0013	Ria Formosa/Castro Marim	
Alosa alosa	PTCON0017	Litoral Norte	
Alosa alosa	PTCON0019	Rio Minho	Relevant
Alosa alosa	PTCON0020	Rio Lima	Relevant
Alosa alosa	PTCON0026	Rio Vouga	Relevant
Alosa alosa	PTCON0036	Guadiana	Relevant
Alosa alosa	PTCON0061	Ria de Aveiro	Relevant

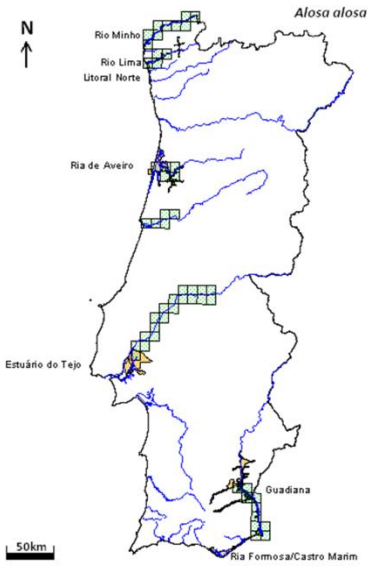


Figure 4.3. Geographic distribution and the SCI (yellow) designated to protect *A. alosa*.

Site PTCON0009 (Estuário do Tejo) includes only the Tagus estuary and does not give good coverage of the area of distribution of allis shad in the river Tagus, that reaches the Belver dam, more then 150 km from the river mouth. The River Mondego, and consequently the A. alosa population of this river, is not included in the Portuguese network of Natura 2000 sites. The situation of A. fallax, in regard to the EU Habitats Directive, is similar to *A. alosa* (Figure 4.4; Table 4.6).

Table 4.6. Natura 2000 sites designated under the Habitats Directive in Portugal for *A. fallax*.

Species	SITE CODE	SITE NAME	Relevance
Alosa fallax	PTCON0009	Estuário do Tejo	Relevant
Alosa fallax	PTCON0011	Estuário do Sado	Relevant
Alosa fallax	PTCON0012	Costa Sudoeste	Relevant
Alosa fallax	PTCON0013	Ria Formosa/Castro Marim	
Alosa fallax	PTCON0017	Litoral Norte	
Alosa fallax	PTCON0019	Rio Minho	Relevant
Alosa fallax	PTCON0020	Rio Lima	Relevant
Alosa fallax	PTCON0026	Rio Vouga	Relevant
Alosa fallax	PTCON0036	Guadiana	Relevant
Alosa fallax	PTCON0061	Ria de Aveiro	Relevant

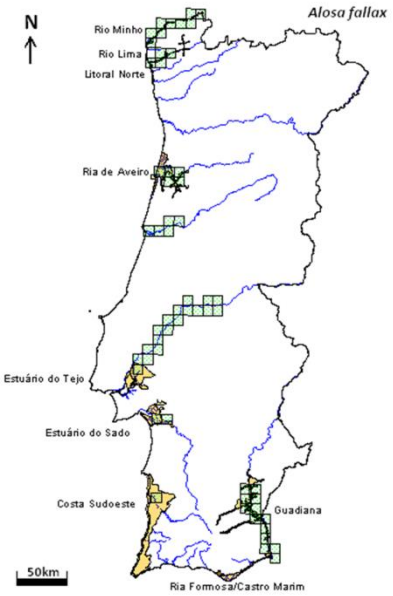


Figure 4.4. Geographic distribution and the SCI (yellow) designated to protect *A. fallax*.

Site PTCON0009 (Estuário do Tejo) only overlaps in a relatively small area of the geographic distribution of *A. fallax* in Tagus river, and there is no Natura 2000 site in River Mondego, an important river in the geographic distribution of the species in Portugal.

Concerning lampreys, the situation of sea lamprey is similar to the shads (Figure 4.5; Table 4.7).

Table 4.7. Natura 2000 sites designated under the Habitats Directive in Portugal for *P. marinus*.

Species	SITE CODE	SITE NAME	Relevance
Petromyzon marinus	PTCON0009	Estuário do Tejo	Relevant
Petromyzon marinus	PTCON0013	Ria Formosa/Castro Marim	
Petromyzon marinus	PTCON0017	Litoral Norte	
Petromyzon marinus	PTCON0019	Rio Minho	Relevant
Petromyzon marinus	PTCON0020	Rio Lima	Relevant
Petromyzon marinus	PTCON0026	Rio Vouga	
Petromyzon marinus	PTCON0036	Guadiana	Relevant
Petromyzon marinus	PTCON0061	Ria Aveiro	Relevant

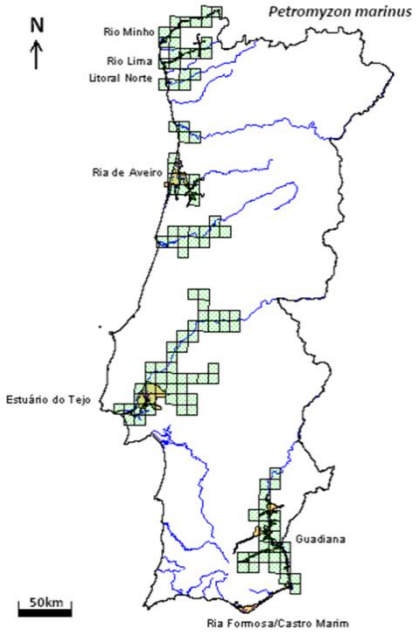


Figure 4.5. Geographic distribution and the SCI (yellow) designated to protect *P. marinus*.

As in shads, site PTCON0009 (Estuário do Tejo) only overlaps in a relatively small area of the geographic distribution of *P. marinus* in Tagus river, and there is no Natura 2000 site in River Mondego, an important river in the geographic distribution of this species in Portugal.

The only Natura 2000 site in Portugal that includes the river lamprey (*L. fluviatilis*) and where the species is considered relevant is Estuário do Tejo (PTCON0009). However once again as the site is restricted to the river estuary it only coincides marginally with the real geographic distribution of the *L. fluviatilis* (Figure 4.6).

Figure 4.6. Geographic distribution and the SCI (yellow) designated to protect *L. fluviatilis*.

Mateus *et al.* (2013) described three new species of the lamprey genus *Lampetra* Bonnaterre, 1788 in Portugal. The species *Lampetra planeri* actually represent a complex of cryptic species, each having smaller geographic ranges than *L. planeri*, and consequently, greater vulnerability to extinction. Table 4.8 represents the sites designated for *L. planeri* (which also include the areas of occurrence of the new described species).

Table 4.8. Natura 2000 sites designated under the Habitats Directive in Portugal for *L. planeri*.

Species	SITE CODE	SITE NAME	Notes	Relevance
Lampetra planeri	PTCON0011	Estuário do Sado	*Lampetra lusitanica* according to Mateus et al. (2013)	Relevant
Lampetra planeri	PTCON0018	Barrinha de Esmoriz	*Lampetra alavariensis* according to Mateus et al. (2013)	Relevant
Lampetra planeri	PTCON0026	Rio Vouga	*Lampetra alavariensis* according to Mateus et al. (2013)	Relevant
Lampetra planeri	PTCON0045	Sicó/Alvaiázere	*L. planeri* and *L. auremensis* according to Mateus et al.(2013)	Relevant
Lampetra planeri	PTCON0061	Ria Aveiro	*Lampetra alavariensis* according to Mateus et al. (2013)	Relevant

The geographic distribution of *L. planeri* is poorly covered by Natura 2000 sites (Figure 4.7), and this is of particular concern as we are in reality dealing with a complex of four different species, some of them without any real and legal protection of the habitat.

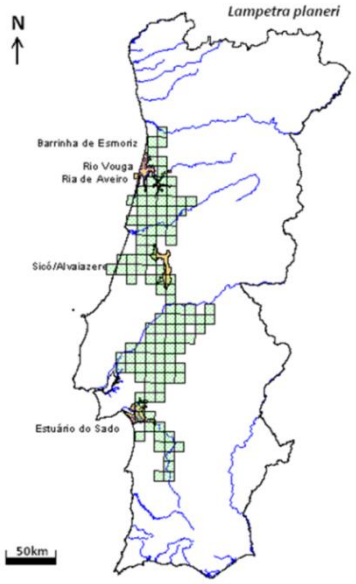


Figure 4.7. Geographic distribution and the SCI (yellow) designated to protect *L. planeri*.

According to article 11 of the Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2, with particular regard to priority natural habitat types and priority species. However, Portugal has no surveillance or monitoring programs directed to fish migratory species, and so the report under de article 17 on the main results of the surveillance under article 11 for annex II, IV and V species is mostly based on expert opinion with no or minimal sampling.

According to the recent (2013 and 2014) recommendations and comments of the Commission about the implementation of the directive to these five species, it is classified as Insufficient moderate (IN MOD): one or several additional Sites of Community Importance (SCI) or extensions of SCI, must be proposed to achieve a sufficient coverage of the Natura 2000 network for these species.

4.2.2 England

The favourable reference area of shad accessible habitat in Great Britain is 2313ha, of which 949ha is in Wales and 1364ha in England. This figure is subject to considerable variation due to flow and should be

considered an indicative value. If river length is used, the equivalent values are 640km total with 279km in Wales and 362km in England, though length may overemphasise smaller and narrower river sections with lower natural accessibility (these values do not include the Rivers Teme and Lugg, which are tributaries of the Severn).

In 1999, 1177ha / 240km of river (50% and 41% respectively) were recorded as having good accessibility. By 2012 these values had improved markedly (Table 4.9; Figure 4.8b) with over half of habitat area having good accessibility. These changes are the result of significant improvements in shad access in the lower-middle Usk.

Table 4.9. Area and length of river in the different shad accessibility categories in 1999 and 2012.

	Area (ha)		Length (km)	
	2012	1999	2012	1999
Good Access	1298 (56%)	1177 (50%)	265 (54%)	240 (41%)
Poor Access	212 (9%)	343 (15%)	96 (10%)	108 (16%)
Inaccessible	802 (35%)	843 (36%)	228 (36%)	241 (39%)

a) Proportion of habitat area, 1999

c) Proportion of habitat length, 1999

b) Proportion of habitat area, 2012

d) Proportion of habitat length, 2012

Figure 4.8. (a-b) Proportions of habitat area accessible and (c-d) Proportion of habitat length accessible to shad in 1999 and 2012. Green = Good access; yellow = poor access; black = inaccessible.

Prospects for Further Improvements

Although the improvements described above are welcome, a significant proportion of potentially suitable habitat in 2012 is still inaccessible or poorly accessible and does not represent favourable conservation status. Two proposed schemes to improve shad access have been proposed: one to amend the drawoff arrangement at Llyn Brianne (River Tywi) so that the water temperature reflects ambient, and two small schemes to ease shad access past bridge footings in the Usk. The potential effect of these are summarised in Figure 4.9. This shows that, if all schemes are implemented, about 2/3 of habitat area and length would have good shad accessibility.

The remaining inaccessible river sections would all be on the Severn, due to various barriers to migration in England. At present, Diglis Weir on the Severn and Powic Weir on the Teme, both near Worcester, are complete barriers to migration (Aprahamian *et al.* 1998).

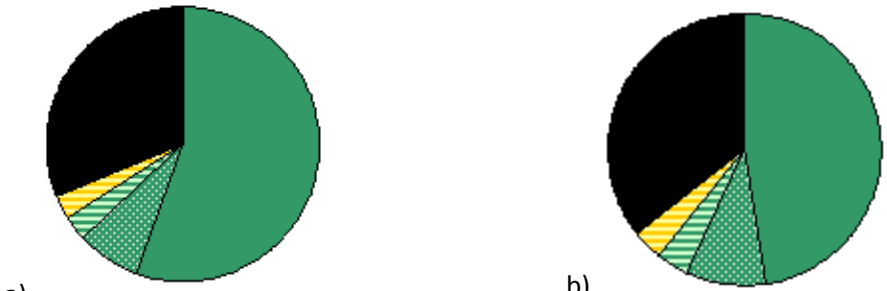


Figure 4.9. Predicted proportion of (a) habitat area and (b) habitat length accessible to shad if planned fish accessibility schemes are implemented. Green = Currently good access; green stippled = good access if Llyn Brianne scheme is implemented; green stripes = good access if Usk schemes are implemented; yellow = poor or better access if Usk schemes are implemented; black = inaccessible. Together, these changes are estimated to represent an improvement of about 22% in river area and 25% river length with good access for shad.

4.2.3 Ireland

The National Parks and Wildlife Service (NPWS) is charged with implementing the Habitats Directive in Ireland. Within the Irish implementing legislation the Fisheries Minister (Minister of Communications, Energy and natural Resources) is tasked with responsibility for surveillance and conservation of the relevant fish species listed in Annex II and IV, *i.e.,* three species of lamprey (sea, river and brook lamprey), three species of shad (allis, twaite and non-migratory Killarney shad), Atlantic salmon and *Coregonus* (*Coregonus autumnalis* – Pollan). Inland Fisheries Ireland (IFI) is the state agency responsible for the protection, management and conservation of Ireland's inland fisheries and sea angling resources and IFI undertakes the surveillance and conservation of the fish species in SACs for the Minister.

The process of designating SACs for fish species was undertaken by NPWS in consultation with IFI. As shads and lamprey species had not received significant investigation prior to the Habitats Directive, the process of SAC designation for these species was based on a combination of expert opinion from aquatic scientists, anecdotal information from commercial fishermen in estuaries and other sources. There was significant synergy, in designating, with decision-making on salmon SACs e.g. rivers were designated for all three lamprey species; river channels and tributaries designated for salmon were commonly also designated for all three lamprey species; estuaries and main stem channels in known or traditional shad waters were also designated for lamprey in view of the diadromous nature of species.

The shad SACs were designated for twaite shad, only, as there were no demonstrated allis shad spawning sites in Ireland. The SACs are situated in the southeast (Figure 4.10) and consist of estuarine waters where populations have been observed spawning, were taken in commercial salmon netting as by-catch, or have been taken in leisure angling. The estuaries are similar in character in being long (by Irish standards i.e. 20 – 40 km), linear expanses of water where a significant column of water is retained at all tidal stages. Information on occurrence of both shad species, and of hybrids, was compiled by King and Roche (2008). The presence of adult twaite, allis and twaite x allis shad has been confirmed in all of the SAC estuaries (King and Roche 2008). Anadromous shads in Irish waters do not appear to travel beyond the upper tidal limit to spawn – in general. There is an artificial barrier to passage (large weir) at the tidal limit on the Barrow SAC but no such barriers occur on the other SACs. Isolated Allis and Twaite shad have been found in freshwater up to 25 km beyond the tidal limit in the Slaney and Munster Blackwater SACs King and Linnane 2004). Anecdotal reports of shads being angled on the River Liffey in Dublin city in the mid-1960s come from two independent sources. However, the estuary of the River Liffey in Dublin is short and the upstream freshwater habitat is inaccessible due to anthropogenic barrier. Individual specimens of Twaite shad have been taken in each of the last three years in the estuary of the R. Boyne, north of Dublin. This catchment has a linear estuary and access into several kilometers of freshwater for spawning. The upper estuarine reaches have habitat comparable to the SAC estuaries where spawning does occur. In Northern Ireland, individual Allis shad have been found in the upper tidal waters of the Foyle estuary, upriver of Derry city, and immediately downstream of a large weir at Sion Mills, circa 5 km upstream of the tidal limit. The catchment area upstream of Sion Mills is very extensive and a minimum of 50 km of channel length would be available to migrating allis or twaite shad if these were able to ascend the Sion Mills barrier.

In all of the Irish water referred above, improvement in fish passage facilities could permit a spatial, and hence genetic, separation of allis and twaite shad in the same catchment. It is envisaged that an additional 25 km of channel would be available for spawning in each river. It would be imperative that the upstream channel provide suitable spawning habitat including extensive areas of fast-flowing shallows over cobble and gravel as well as pool areas and backwaters (Maitland and Hatton-Ellis 2003). Such terrain is present in the Rivers Nore, Suir, Slaney and Blackwater whereas dredging and navigation weirs on the riverine River Barrow render its freshwater areas unsuitable as spawning habitat. In Northern Ireland, access into freshwater areas upstream of the barrier at Sion Millls would provide access to large areas of highly suitable shad spawning waters. The addressing of such obstructions may be required under both Water Framework Directive and Habitats Directive.

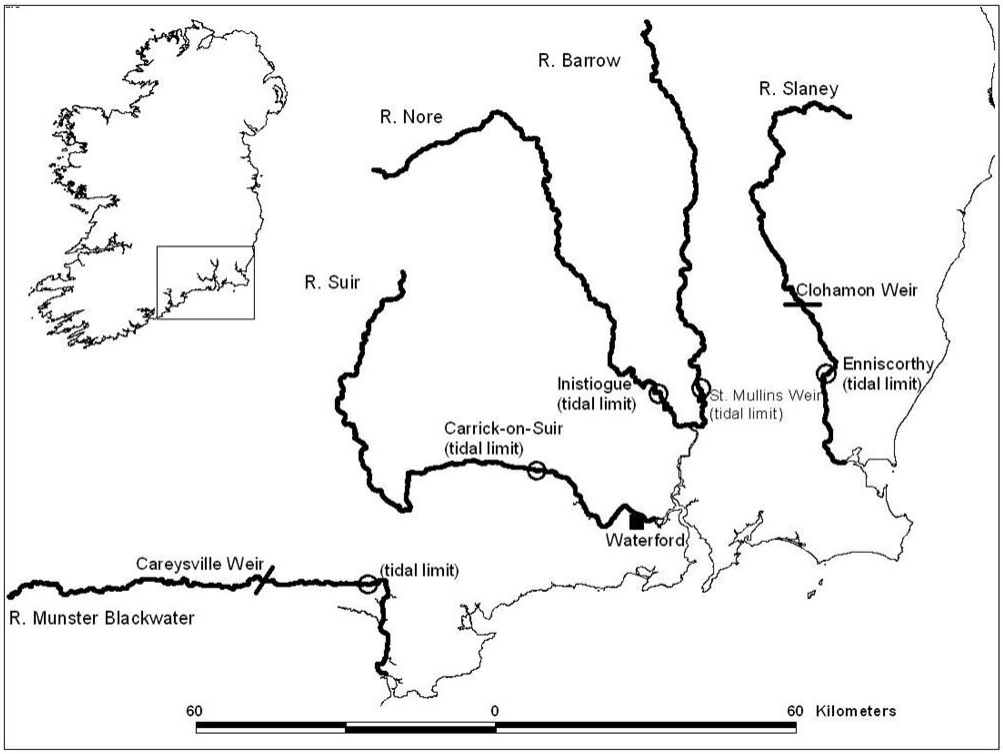


Figure 4.10. Special Areas of Conservation for twaite shad in Ireland.

The SACs for lamprey species (Figure 4.11) are more widespread than the shad SACs but the lamprey network does include the waters included for shads.The majority of the lamprey SACs are designated for all three species.

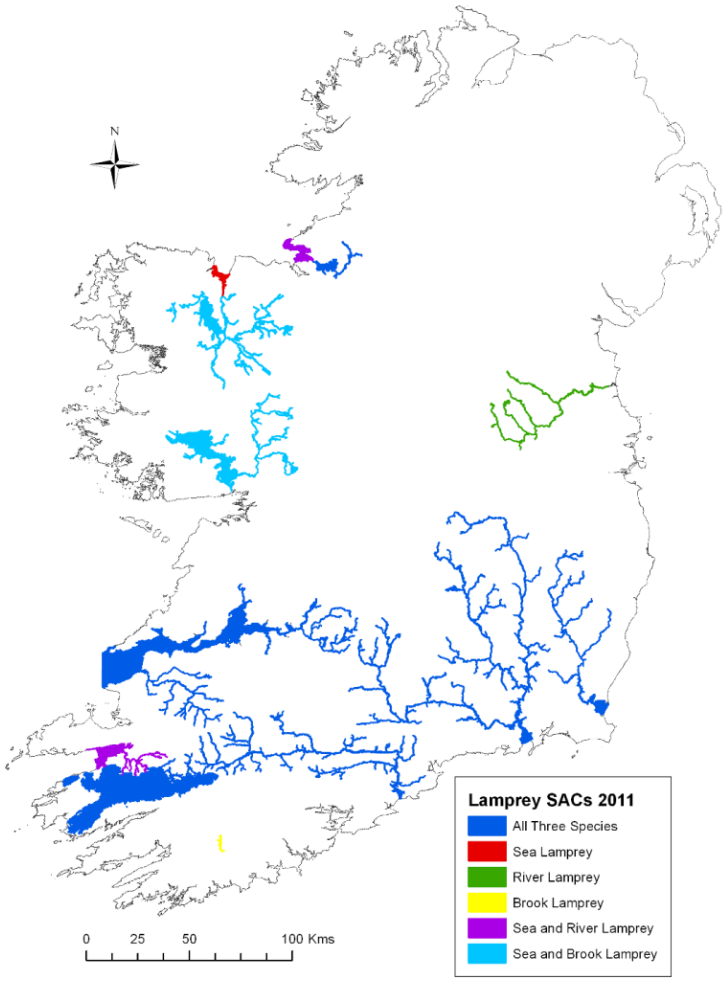


Figure 4.11. Special Areas of Conservation for lampreys in Ireland.

The discrimination of brook and river lamprey is problematic for Ireland, as for other EU member states – discrimination being easy in the adult stage but not possible in the field for larvae of the two types. River lamprey adults have been captured in scientific sureys on the Irish east-coast estuaries and in the large Shannon estuary. However, the absence of records of river lamprey adults from the major catchments of the west (Corrib) and north-west (Moy) has led to these catchments not being listed as SACs for this species.

Catchment-wide surveys of larval lamprey status, including identification of sea lamprey larvae, was commissioned by the NPWS in the 2003 – 2007 period covering all of the SAC catchments (King and Linnane 2004; King 2006; O'Connor 2004, 2006a, 2006b, 2007). A further series of catchments, non-SAC,

have been surveyed by IFI in the 2009 – 2013 period. This entire series of data permitted IFI to report, under Article 17 of Habitats Directive, to the EU in 2013 – the report covering the national territory, as required, i.e. both SAC and non-SAC catchments.

In the reporting period 2013 – 2018, IFI has commenced to re-survey the large lamprey SAC catchments with a view to examining 'trends' in population distribution, density and structure, as required by Article 17 of the Directive.

4.2.4 Conservation status of lampreys and shads in Europe for the period 2007-2012

Shads and lampreys are listed in EU Habitat Directive. Article 11 of the Habitats Directive requires Member States to monitor the habitats and species listed in the annexes (habitats in the Annex I and species in the Annexes II, IV and V), and Article 17 requires a report to be sent to the European Commission every 6 years following an agreed format. The core of the 'Article 17' report is assessment of conservation status of the habitats and species targeted by the directive. The assessment is made based on information on status and trends of species populations or habitats and on information on main pressures and threats. We present available data reported for the period 2007-2012 (http://bd.eionet.europa.eu/ article17/reports2012/) in Figure 4.12 to Figure 4.15. This should inform about the distribution of the species throughout Europe as well as their conservation status.

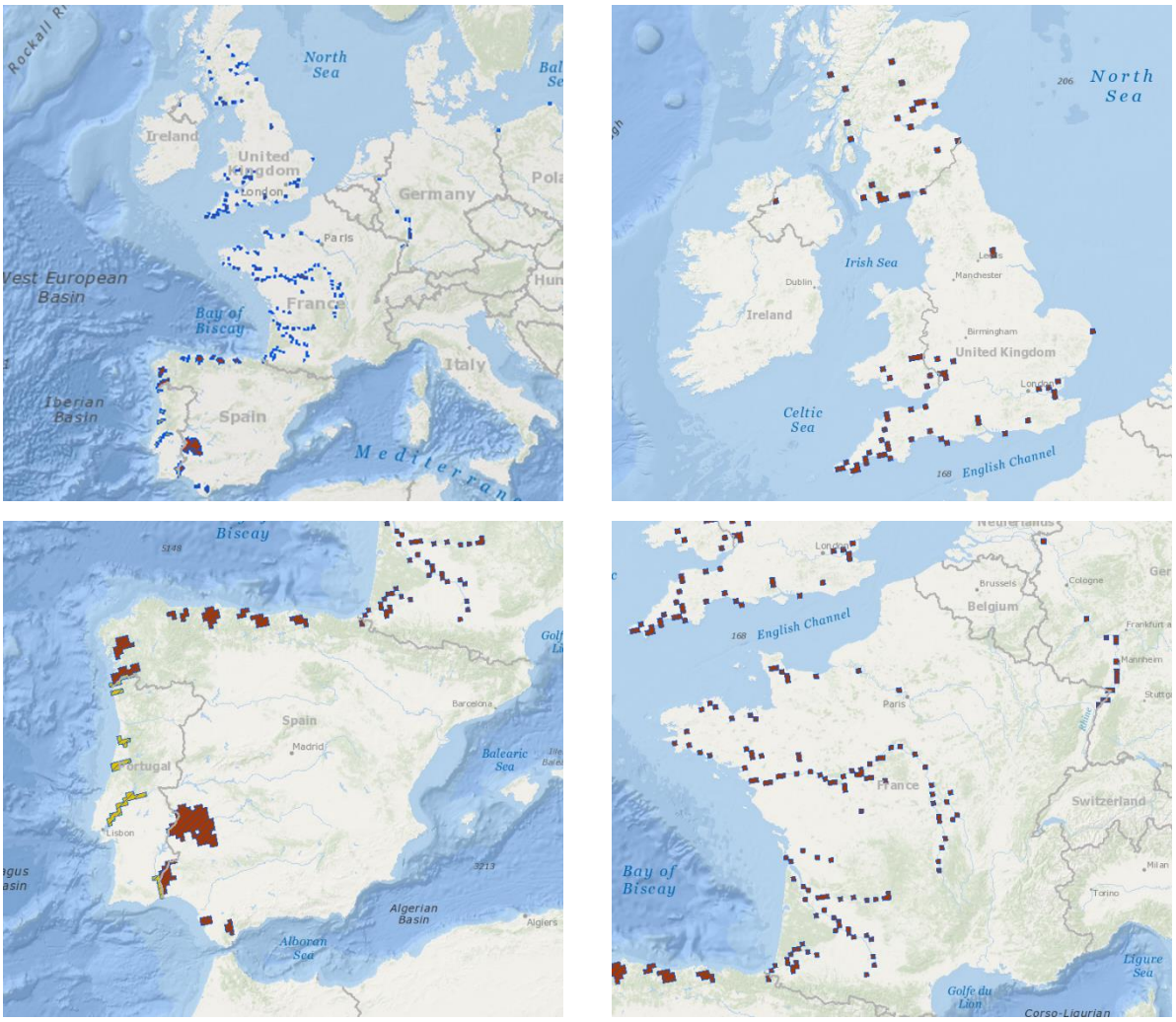


Figure 4.12. Conservation status of *Alosa alosa* at the European level for the 2007-2012 period, reported by Member States (available at http://bd.eionet.europa.eu/article17/reports2012/). Green=Favourable; yellow=Unfavourable-Inadequate; red=Unfavourable-Bad; grey=Unknown.

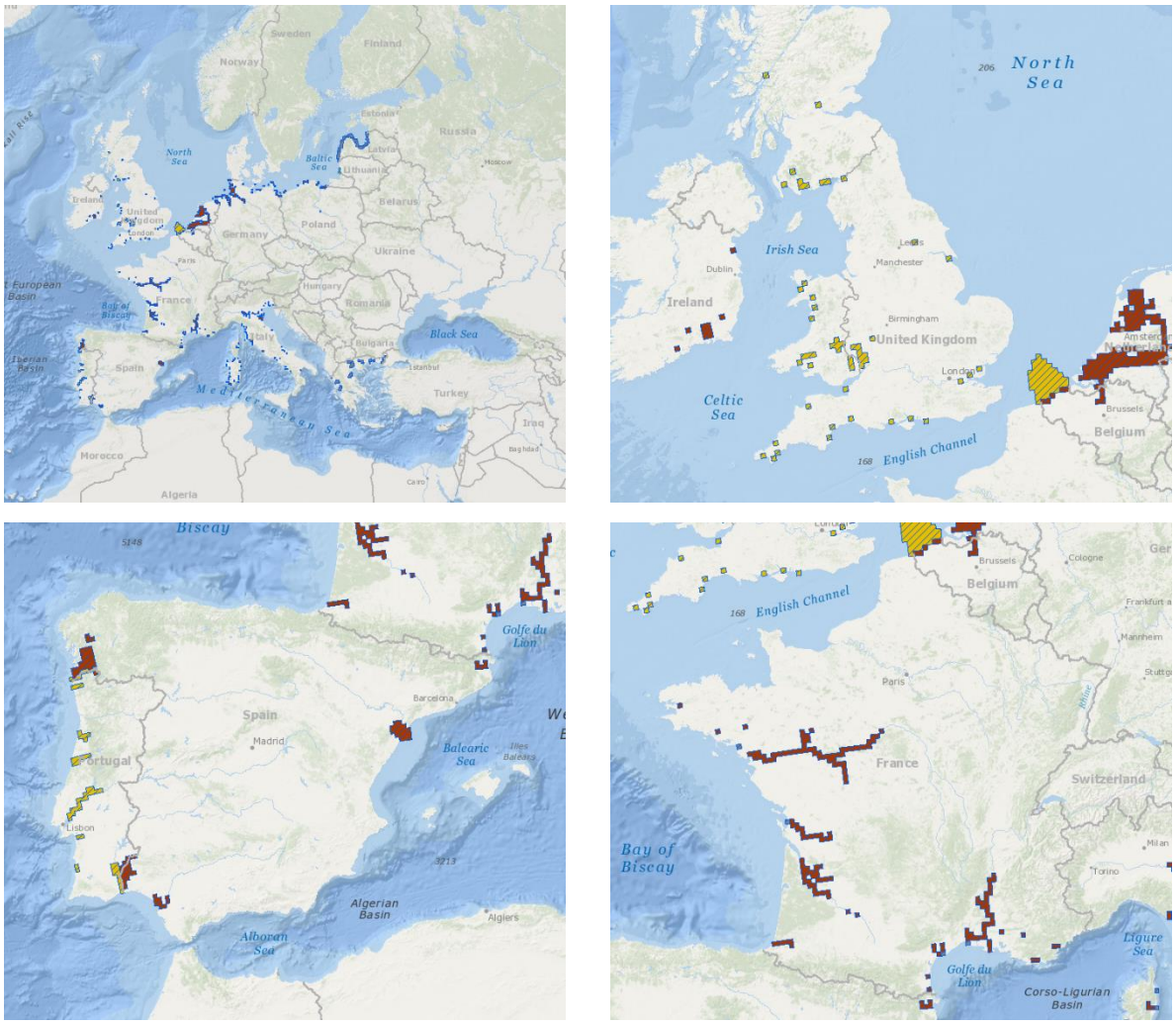


Figure 4.13. Conservation status of *Alosa fallax* at the European level for the 2007-2012 period, reported by Member States (available at http://bd.eionet.europa.eu/article17/reports2012/). Green=Favourable; yellow=Unfavourable-Inadequate; red=Unfavourable-Bad; grey=Unknown.

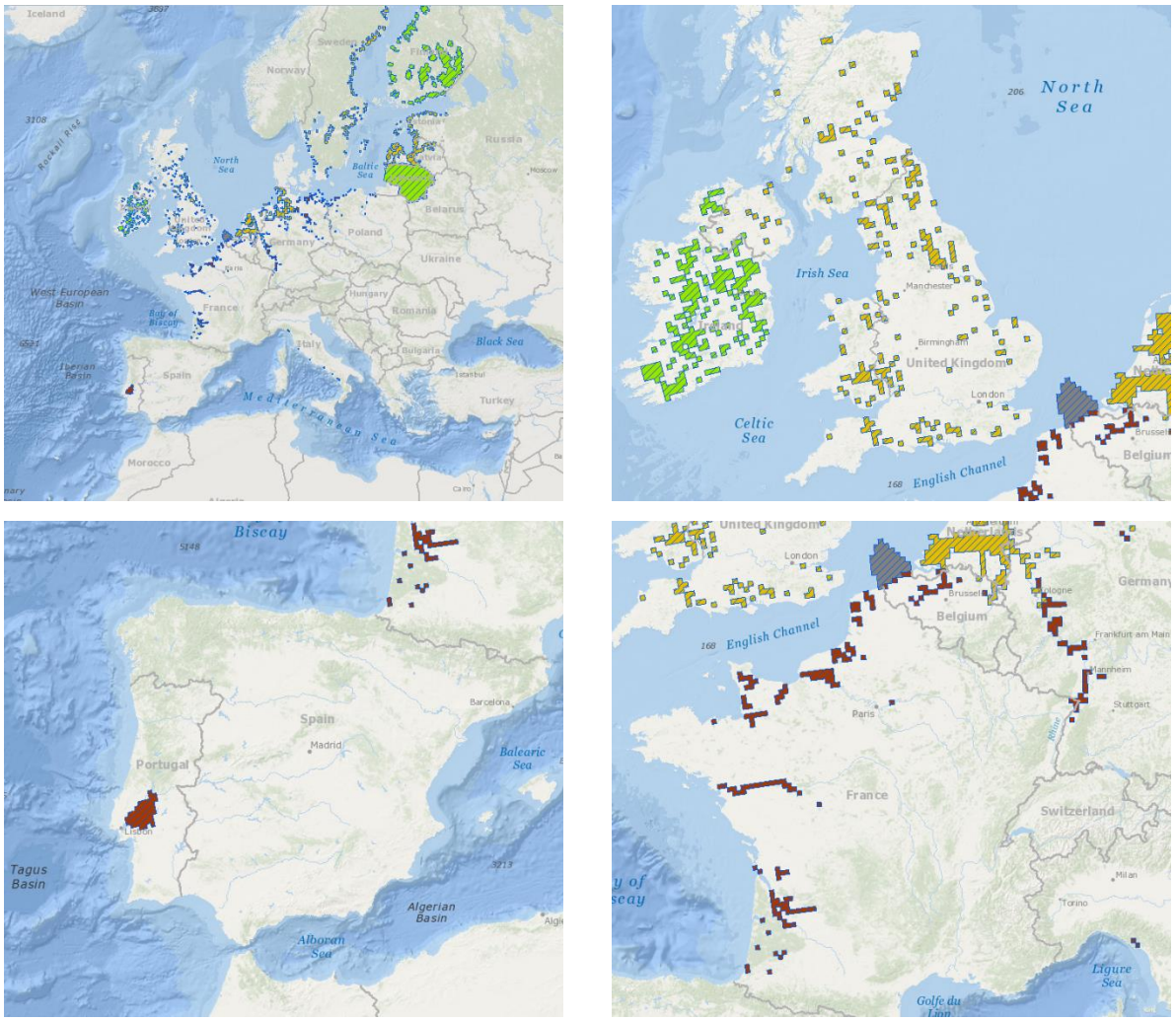


Figure 4.14. Conservation status of *Lampetra fluviatilis* at the European level for the 2007-2012 period, reported by Member States (available at http://bd.eionet.europa.eu/article17/reports2012/). Green=Favourable; yellow=Unfavourable-Inadequate; red=Unfavourable-Bad; grey=Unknown.

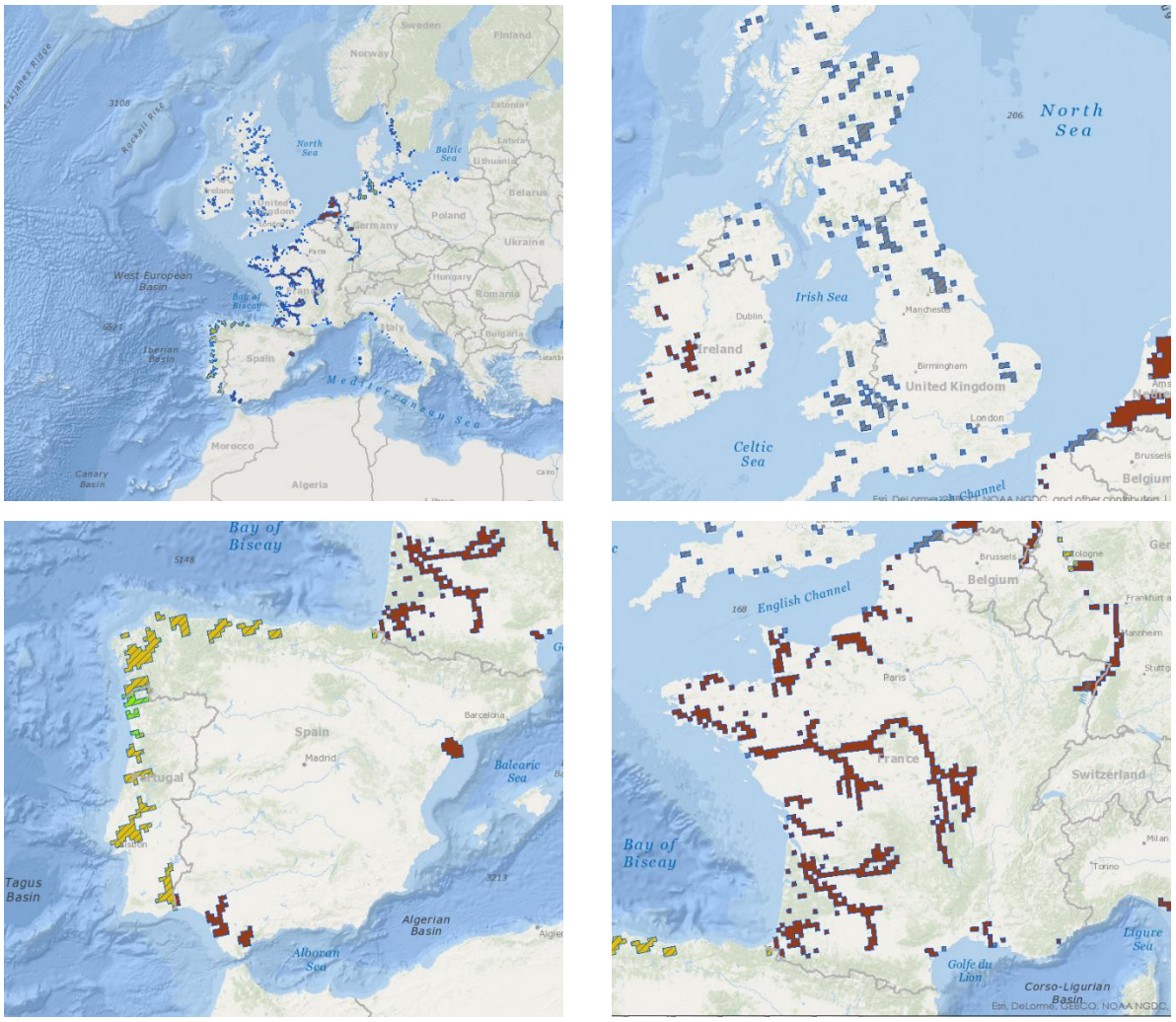


Figure 4.15. Conservation status of *Petromyzon marinus* at the European level for the 2007-2012 period, reported by Member States (available at http://bd.eionet.europa.eu/article17/reports2012/). Green=Favourable; yellow=Unfavourable-Inadequate; red=Unfavourable-Bad; grey=Unknown.

4.3 PROTECTION AND FISHERIES REGULATION

In Europe, lampreys and shads are protected by several directives. In addition to the Habitats Directive of 1992, the Bern Convention is another important piece of legislation. Also, the following legislation, concerning both freshwaters and the marine environment, includes both shads and lampreys.

1) **Bern Convention (Convention on the Conservation of European Wildlife and Natural Habitats)** – The Bern Convention is a binding international legal instrument in the field of nature conservation, covering most of the natural heritage of the European continent and extends to

some States of Africa. It aims to conserve wild flora and fauna and their natural habitats, as well as to promote European co-operation in this field.

2) **Water Framework Directive** (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy) – European Water Policy has undergone a thorough restructuring process, and a new Water Framework Directive adopted in 2000 will be the operational tool, setting the objectives for water protection for the future.

3) **European Red List** – The European Red List is a review of the conservation status of c. 6,000 European species (mammals, reptiles, amphibians, freshwater fishes, butterflies, dragonflies, and selected groups of beetles, molluscs, and vascular plants) according to IUCN regional Red Listing guidelines. It identifies those species that are threatened with extinction at the European level – so that appropriate conservation action can be taken to improve their status.

4) **OSPAR (Convention for the Protection of the Marine Environment of the North-East Atlantic)** - The OSPAR Convention is the current legal instrument guiding international cooperation on the protection of the marine environment of the North-East Atlantic. Work under the Convention is managed by the OSPAR Commission, made up of representatives of the Governments of 15 Contracting Parties and the European Commission, representing the European Union.

5) **HELCOM (Baltic Marine Environment Protection Commission)** – HELCOM is the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area, the http://helcom.fi/about-us/convention. The Contracting Parties are Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden. HELCOM was established about four decades ago to protect the marine environment of the Baltic Sea from all sources of pollution through intergovernmental cooperation.

6) **Bonn Convention or CMS (Convention on the Conservation of Migratory Species of Wild Animals)** – As an environmental treaty under the aegis of the United Nations Environment Programme, CMS provides a global platform for the conservation and sustainable use of migratory animals and their habitats. CMS brings together the States through which migratory animals pass, the Range States, and lays the legal foundation for internationally coordinated conservation measures throughout a migratory range.

7) **UNCLOS (United Nations Convention on the Law of the Sea)** – The http://www.un.org/Depts/los/convention_agreements/texts/unclos/closindx.htm. This lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources. It enshrines the notion that all problems of ocean space are closely interrelated and need to be addressed as a whole.

4.3.1 Fisheries regulations in Portugal

There are three different legal frameworks concerning fisheries in Portugal that apply in different geographic areas:

1) Marine fisheries regulations that are applicable in the areas under maritime authority, that include some downstream parts of rivers and estuaries (Decreto Regulamentar n.º 43/87, 17th July);
2) River Minho is under maritime authority but has a special regulation due the fact that it is a border river with Spain (Decreto n.º 8/2008, 9th April);
3) Inland waters fisheries regulations applying to all waters outside the areas under maritime authority (Lei n.º 2097, 6th June 1959 and Decreto n.º 44623, 10th of October 1962).

4.3.1.1 *Inland waters fisheries*

There is a regular and important commercial fishing activity in inland waters directed to migratory fish species like *Petromyzon marinus, Alosa alosa* and *A. fallax.* The species of genus *Lampetra* are not target species for commercial or recreational fisheries.

In addition to the general rules included in the law concerning inland waters fisheries, special areas for commercial fisheries (ZPP – Zonas de Pesca Profissional) of migratory species (mainly sea-lamprey and shads) were created where special restrictions apply. These special areas (ZPP) are located in the main rivers of the geographic distribution of these species and are marked in yellow on the map below (Figure 4.16).

These areas have regulations issued by decree (Table 4.10), but each year notices are published with specific rules. The specific rules that can be adapted every year are, in general terms, the following:

1. Number of fishing permits;
2. Authorized number of fish caught by fisherman, per species;
3. Fishing season, per species;
4. Authorized fishing methods and fishing gear.

Table 4.10. Commercial Fishing Areas – ZPP (Zonas de Pesca Profissional) in Portugal.

ZPP	Decree
ZPP Rio Lima	Portaria n.º 929/99, 20th October
ZPP Rio Cávado	Portaria n.º 159/99, 9th March
ZPP Rio Vouga	Portaria n.º 1080/99, 16th December
ZPP Baixo Mondego	Portaria n.º 164/99, de 10th March
ZPP Médio Mondego	Portaria n.º 84/2003, de 22nd January
ZPP Rio Tejo – Constância / Barquinha	Portaria n.º 461/2007, de 18th April
ZPP Rio Tejo - Ortiga	Portaria n.º 444/2004, de 30th April
ZPP Rio Guadiana	Portaria n.º 1274/2001, de 13th November

Figure 4.16. Special areas for commercial fisheries (ZPP – Zonas de Pesca Profissional) (yellow) in Portugal.

4.3.1.2 *Internal non maritime waters*

As said in each zone of internal non maritime waters, namely in the north where fishing for diadromous fishes is relevant, there are specific regulations establishing the characteristics of the gears that can be used to fish lampreys and shads and fishing season. In

http://www.dgrm.min-agricultura.pt/xportal/xmain?xpid=dgrm it is possible to access the different regulations and fishing season when it is fixed.

In internal non maritime areas it is not possible to increase the number of vessels licensed and there are no new licenses to use trammel nets for lampreys and shads. So, the tendency will be for a reduction in the number of vessels allowed to fish these species. Minimum landing sizes established by Portaria nº 27/2001 are: lampreys – 35 cm and shads – 30 cm.

In the international River Minho, an Edital is published each year with the rules for the next year, including minimum landing size, fishing season and gears that can be used.

In the ocean drift trammel nets are not allowed and catches directed to the species concerned are not frequent, with the exception of allis shads, that show important landings, especially during fish

aggregations before they enter the rivers. So, the regulation applied in the sea for shads should be changed in accordance to this new evidence.

In addition, fishing for lampreys and shads is not allowed in recreational fisheries (Portaria nº 14/2014, 23th January).

4.3.2 Fisheries regulations in NW Spain

Specific rules for *P. marinus* to management-control of the commercial fisheries are, in general terms, the following:

1. Restricted to specific sections in the river Ulla and Minho basins
2. Fishing period
3. Limited number of boats-fishermen
4. Type and number of gears.

Specific conservation measures (direct conservation efforts) for *A. fallax* and *A. alosa* are related to fishing management-control:

1. Restricted to specific sections in the Ulla and Minho rivers
2. Fishing period
3. Limited number of boats-fishermen
4. Type and number of gears, hooks.

4.4 HABITAT RECOVERY INITIATIVES

4.4.1 Fishway in River Mondego, Portugal

The Açude-Ponte Coimbra dam is a 6.20 m high gate weir built in the River Mondego mainly for industrial, water supply, agricultural and flood control purposes. Since its construction, this structure blocked the migration of several commercially and ecologically important species, including the sea lamprey, the allis and the twaite shad, limiting the distribution of these and other diadromous and potamodromous fish species inhabiting the Mondego river basin. In 2011, a vertical-slot type fishway (Figure 4.17), managed by the Portuguese Environment Agency (APA), was built to restore river connectivity and, since then, its efficiency for the target species is being evaluated using several methodologies, namely visual counts, bio-telemetry (radio, physiological electromyogram-EMG, PIT Tags), electrofishing surveys and enquiries to the local commercial fishermen. Results from the first three years of post-construction monitoring indicate that the fishway actually increased the available area for diadromous species in the River Mondego. Visual counts revealed that, in 2013, 1407204 fish successfully negotiated the infra-structure (ca. 900000 in the upstream direction). These included several autochthonous species, namely, *P. marinus, Alosa sp., A. anguilla, Salmo trutta, Luciobarbus bocagei, Pseudochondrostoma polylepis, Liza ramada*.

During the 2013 spawning season 8333 lampreys used the fishway, and in 2014 this number increased to nearly 22000 lampreys. A statistical model developed with this data clearly shows that the weir discharges significantly influence the migratory behavior in the vicinity of the fishway, limiting its efficiency during high discharge periods. About 7500 *Alosa* sp. specimens used the fishway in the 2013 spawning season, whereas only 3406 individuals used this infrastructure in 2014 (Almeida *et al.* 2015).

Electrofishing campaigns conducted before and after fishway construction detected a sixteen-fold increase, between 2012 and 2014, in the relative abundance of sea lamprey larvae upstream of the weir. Within the project, almost 50 local fishermen were contacted, from a total of 93 individual licences, and around 20% of the commercial fishermen are actively providing their capture data, but efforts are continuously being made to increase this number. Studies for monitoring the fishway efficiency also include the use of a PIT-tag antenna system installed at the infrastructure, and the use of electromyogram transmitters (EMG) to analyze high definition data concerning sea lamprey behavior and muscular effort during fishway negotiation (Almeida *et al.* 2015). Results from this study can help to improve the success of the Açude-Ponte Coimbra dam fishway in restoring migratory fish populations in the River Mondego and are being promoted as what is considered to be a reference approach to other similar structures spread along Portuguese rivers.

Figure 4.17. Fishway in Açude-Ponte Coimbra dam, River Mondego, Portugal. a) and b) lateral and upside views; c) lampreys passing through the window of the monitoring room (Photos: Pedro R. Almeida).

4.4.2 Habitat restoration for diadromous fish in River Mondego, Portugal

The conservation of diadromous fish populations depends upon the implementation of management actions that are spatially representative of these species ecological needs. Because freshwater, estuarine and coastal habitats are administratively linked to different Portuguese governmental agencies, often belonging to different ministries, the application of an integrated management plan is particularly difficult, especially when it involves changes in fisheries regulations, rehabilitation of habitats and poaching eradication (i.e., coordination between supervising bodies).

The project ***Habitat restoration for diadromous fish in River Mondego*** (2013-15) is coordinated by the University of Évora with the technical-scientific advice of MARE – Marine and Environmental Sciences Center, and it was funded by the Ministry of Agriculture and Sea, and co-founded by the European Fisheries Fund through PROMAR 2007-13. The project has 11 institutional partners, namely the

Portuguese Environment Agency (APA), the Mora Freshwater Aquarium (FM), the Foundation of the Faculty of Sciences of the University of Lisbon (FFCUL), the Portuguese Sea and Atmosphere Institute (IPMA), the Energies from Portugal (EDP), the Portuguese Fisheries Authority (DGRM), the Portuguese Institute for Nature Conservation and Forests (ICNF), the Sea Lamprey Brotherhood, and the municipalities of Penacova, Vila Nova de Poiares and Coimbra.

The main goal of the project is the implementation of an integrated management approach that will ensure the compatibility between the conservation of the diadromous fish, and all the other water uses in this watershed, namely, hydroelectricity production, water supply, commercial fisheries and different recreational purposes (e.g., recreational fisheries and aquatic sports like kayaking). This project was boosted by the recent construction (i.e. 2011) of the fish passage at the Açude-Ponte Coimbra dam (see above), which enabled the migratory fish to surmount this impassable dam built in 1981. The main action of this project involves building nature-like fish passage facilities in five weirs, one of which is located downstream of Açude-Ponte Coimbra dam, and the remaining four located upstream (Figure 4.18 and 4.19), including the complete removal of one of the weirs. At the same time, it is also within the project objectives to contribute to a sustainable fishery of sea lamprey, allis and twaite shad by introducing a management scheme that links the administrative governmental agencies responsible for fisheries regulations in estuaries (DGRM) and freshwater stretches (ICNF) with fishermen's, with the concomitance and advice of research institutions working with diadromous species. This project also intends to increase the public awareness concerning the conservation of diadromous fish, as well as the reduction of illegal fishing in River Mondego.

Figure 4.18. Two of the weirs located upstream of Açude-Ponte Coimbra dam that are being modified in order to build nature-like fish passages: a) Penacova and b) Louredo weirs (Photos: Pedro R. Almeida).

Figure 4.19. Construction of a nature-like fish passage in River Mondego (Penacova weir, July 2015) (Photo: Pedro R. Almeida).

4.4.3 Fish passage in Ireland

Inland Fisheries Ireland (IFI), as the state fisheries agency, is conscious of the importance of barriers to fish passage and the relevance of the Habitats Directive (for diadromous Annex II species e.g. salmon, sea and river lamprey; twaite and allis shads). IFI has identified the need for a geo-referenced national inventory of barriers and has developed a standard protocol for field data gathering directly onto ruggedized lap-top computers. In the light of an initial catchment survey in the Nore catchment, where up to 500 barriers were field-surveyed (Gargan *et al.* 2011) it is evident that a complete national picture may take some time to compile. A two-tier survey method is proposed, the first being a basic survey of barrier location, image capture and basic dimensions onto lap-tops for database storage. The second tier involves use of the SNIFFER barrier porosity tool. This is a substantially-more detailed procedure. At present, IFI has commenced surveys of the major barriers to migratory fish passage in the main-stem SAC rivers using SNIFFER. In addition, where artificial barriers are to be removed or modified it is proposed to undertake a SNIFFER survey prior to removal as well as subsequently, in similar water conditions.

The experience in regard to sea lamprey in Ireland is that the species arrives at a time of likely low flow conditions, is impeded by the first major barrier to passage in the channels it enters and that a

concentration of spawning effort is observed downstream of major barriers to passage (see Gargan *et al.* 2011). Telemetry studies have shown that sea lamprey will explore at a barrier in an attempt to pass upstream. Failure to ascend led to some fish migrating downstream and entering other tributary channels (Almeida *et al.* 2002). Similar findings were observed in telemetry studies in the River Mulkear (Rooney *et al. in press*) during an EU LIFE-funded project entitled ***Restoration of the Lr. Shannon SAC for Sea lamprey, Atlantic salmon and European otter*** (MulkearLIFE project LIFE07 NAT/IRL/000342) (http://mulkearlife.com/). That project was developed to address conservation management issues relating to otter, Atlantic salmon and sea lamprey within the Lower River Shannon SAC. Substantial annual spawning effort by sea lamprey took place downstream of the first barrier to passage on the River Mulkear and a catchment-wide ammocoete survey located only two specimens of sea lamprey – one downstream of this barrier and one in the lower reaches of the catchment (http://www.fisheriesireland.ie/fisheries-research-1/390-habitats-directive-report-2012-1/file).

Two barrier modification strategies were undertaken – one on each of the two significant barriers to sea lamprey passage in the lower reaches of the River Mulkear. One used a plastic sheeting moulded to the form of egg-boxes which was bolted to stainless steel sheeting attached to part of the face of the first weir (Figure 4.20). The vertical structures on the mould provided a baffle for sea lamprey, creating areas of reduced velocity as well as an opportunity to flex themselves against these structures in swimming upstream. Direct visual observation during hours of darkness, the time of maximum passage attempts, showed a preference by the sea lamprey for the textured plastic sheeting as an ascent route.

Figure 4.20. Plastic sheeting moulded to the form of egg-boxes placed in Annacotty weir, River Mulkear.

The second strategy, employed at the second major weir located approximately 2 km upstream of the first, initially proposed the construction of a 'rock ramp' – a re-design of reduced gradient with a natural channel bed of stone - to be installed across part of the weir (Figure 4.21). In the end, an alternative was agreed and the weir was breached, in part. This permitted an unimpeded upstream passage for sea lamprey and Atlantic salmon, a re-creation of the natural flow pattern in line with Water Framework Directive, and a retention of portion of the architectural heritage of the cut-stone weir. There was an extensive use of spawning habitat in the upstream reaches of the Mulkear catchment in 2014 in a summer of low flow conditions following completion of the two modifications to passage. The use of rock ramps for fish passage is also being implemented at other anthropogenic barriers in Irish rivers where this strategy is considered suitable. The impetus comes primarily in the context of Atlantic salmon conservation but the rock-ramp strategy is one that is suited to both salmon and sea lamprey.

Figure 4.21. Rock ramps installed in a) Abbeyfeale, Feale catchment. Feale is a salmon and sea lamprey catchment under Habitats Directive, and b) King's River, Nore catchment.

The requirement for unimpeded access into, at least, 75% of main stem SAC channels is identified in Ireland's conservation management plans for sea lamprey. The current situation is far from attaining this. Currently, barrier assessment using the SNIFFER protocol (SNIFFER undated) is being undertaken on the major barriers in SAC channels (Figure 4.22). The outcomes will inform management decisions on barrier modification to facilitate migratory fish passage.

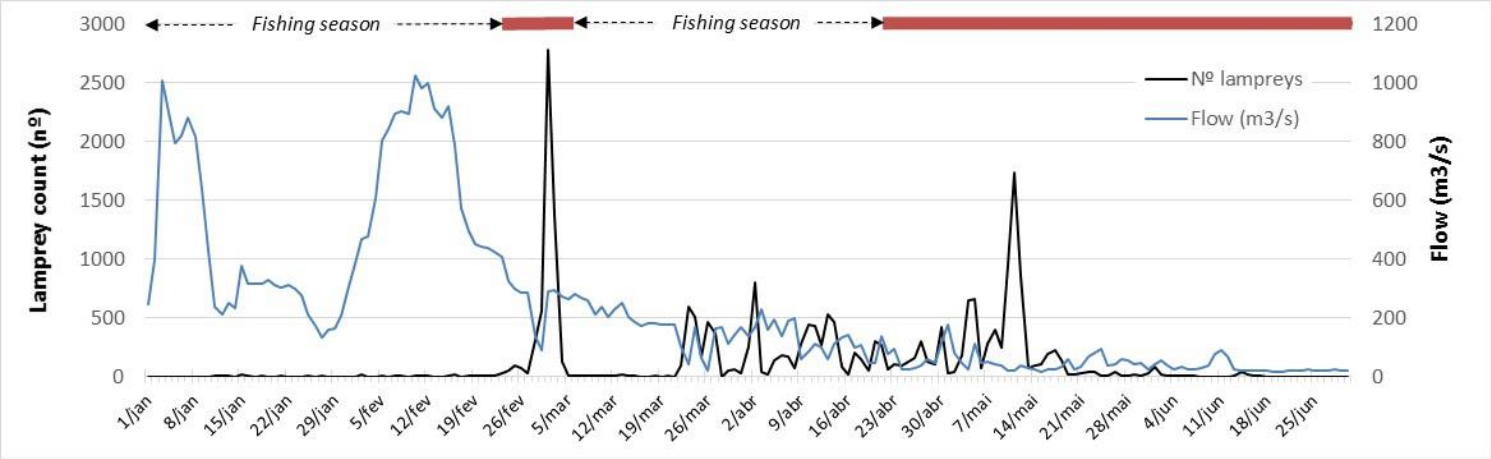
Figure 4.22. SNIFFER survey at a barrier to salmon, sea lamprey and shad in River Munster Blackwater: a) taking levels and b) taking velocity readings.

4.5 OTHER CONSERVATION EFFORTS

4.5.1 Intermediate closed fishing season in River Mondego, Portugal

Commercial fisheries regulations in Portugal define in general the official fishing season for sea lamprey as between the beginning of January and the end of April. In the River Mondego, during the 2014 spawning season, a 10-day interruption (beginning of March) was implemented during the peak of the sea lamprey spawning migration (Figure 4.23a). For shads, in the same watershed and during the same spawning season, fishing was allowed during the period of March-May, with a 10-day interruption at the end of April beginning of May (Figure 4.23b). For sea lamprey and shads, capture is allowed in both estuaries and in designated areas in fresh water.

a)



b)

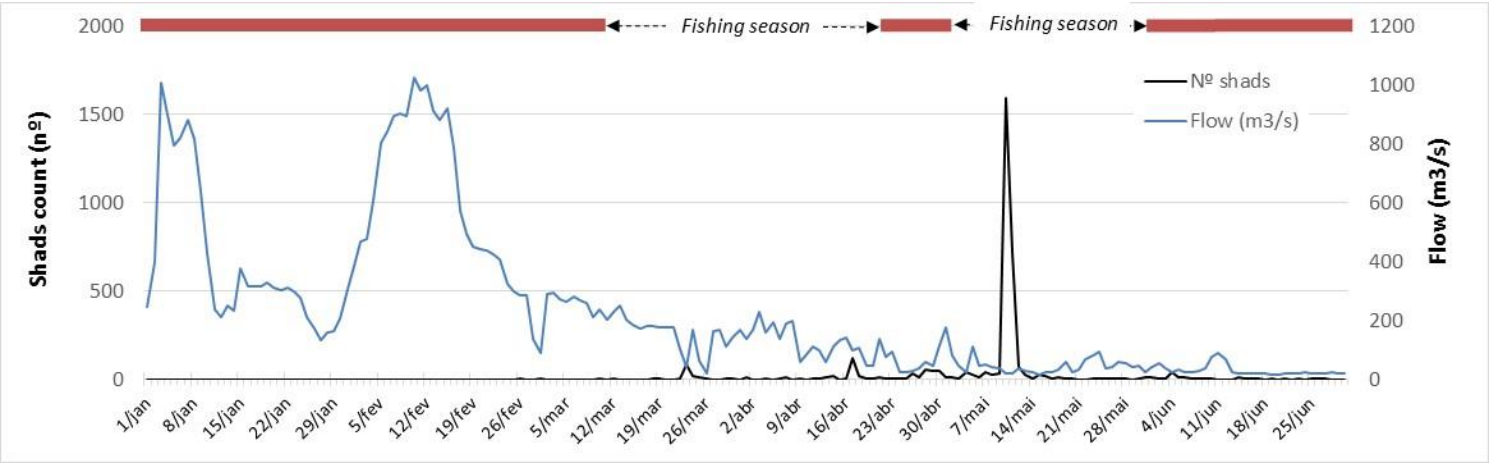


Figure 4.23. Number of (a) sea lampreys (—) and (b) shads counted at the Açude-Ponte Coimbra dam fishway (River Mondego, Portugal) during the 2014 spawning season. Also represented the average flow (—) released by the dam and the calendar of the fishing season and the closed fishing season (▬) including the intermediate (10 day period) closed fishing season defined during the peak of the sea lamprey spawning migration (Almeida *et al.* 2015).

The intermediate closed fishing season defined at the peak of the sea lamprey and shads spawning migration is being implemented in the River Mondego since 2012. The proper evaluation of this management measure is not easy because it depends on the count of the fish that move through the Açude-ponte dam fishway in relation to the open and close fishing periods. The efficiency of the fishway for sea lampreys and shads is strongly influenced by the flow released by the Açude-Ponte Coimbra dam, increasing substantially with lower flows approximately below 50 m^3 s^{-1} (Cardoso 2014). This variability of efficiency with flow makes difficult a direct comparison between the closure of the fishing at the peak of the spawning migration and the number of animals that successfully move through the commercial fisheries area located at the lower stretch of the River Mondego (assessed by the number of lampreys that used the Açude-Ponte Coimbra dam fishway during the subsequent days).

A sea lamprey takes, on average, approximately 5 days to cover the 45 km stretch between the River Mondego mouth and the Açude-Ponte Coimbra dam (Almeida *et al.* 2000). In Figure 4.23, a relation between the number of sea lampreys that were counted moving through the fishway, the flow released by Açude-Ponte Coimbra dam, and the open-close fishing season is presented. About 5000 sea lampreys moved through the fishway between 28th February and 3rd March 2014. The closed fishing season started on the 24th of February and extended to the 5th of March, so 4 days after this fishing hiatus the number of sea lampreys moving through the fishway started to increase considerably. A peak of movements was detected on the 2nd of March (2779 sea lampreys counted at the fishway), exactly 7-days after the beginning of the intermediary close fishing season. We prefer to use a precautionary approach when interpreting these results, by not associating this peak of animals counted at the fishway only with the interruption of the fishing season, because this higher frequency of movements at the fishway was also detected during a period where the flow decreased considerably, increasing the fishway efficiency particularly in what concerns it's attractability (Cardoso 2014).

For shads, a peak of movements was detected 19 days after the beginning of the closed fishing season for these species (10 days between 22 April and 1 May). For these species we have no information concerning the amount of time needed to cover the 45 km stretch since they enter the Mondego Estuary until Açude-Ponte Coimbra dam . Nevertheless, 68% (2314) of the shads that move through the fishway did it during only 2 consecutive days (10 and 11 of May). To unequivocally relate this peak of animals that used the fishway with the management of fisheries (i.e., intermediate close fishing period), perform downstream additional information on the migratory behaviour (i.e. travel speed) needs to be gathered.

4.5.2 Restocking of allis shad in the Rhine river system

Allis shad was originally found in almost all of Europe's Atlantic tributaries, including the Rhine, which at the beginning of the 20th century, held one of the most important allis shad populations in the species' northern distribution range. Within 30 years, however, this population had collapsed due to over-fishing, increased river pollution, destruction of spawning grounds and barriers to migration such as dams and weirs. Two LIFE projects have been undertaken to recover this species in the Rhine, one in the period 2008-2010 and the other from 2011 until 2015. The first project, entitled ***The re-introduction of***

allis shad (Alosa alosa) in the Rhine System (LIFE06 NAT/D/000005), involving partners and contributors from three Rhine-bordering countries - Germany, France and the Netherlands, developed a breeding programme in south-west France, where the species is still found naturally, and then planned and carried out the transportation of larvae from France to Germany and the restocking of the Rhine river system. Over the three breeding seasons covered by the project, the LIFE team caught a total of 644 spawning shad through fish lifts at two sites on the Garonne and Dordogne rivers in France. The allis shad were treated with hormones to speed up spawning and the fertilised eggs kept in breeding tanks. The emerging fry swam into hatchery tanks where they were fed with brine shrimps (*Artemia* spp.), which were also reared in tanks. The first restocking of the Rhine occurred in June 2008 and was repeated and expanded over the following two years. In total, some 4.8 million larvae were released. In the autumns of 2010 and 2011, a total of 30 juveniles were caught in the lower Rhine near the German/Dutch border, representing the first allis shad to be caught there for more than 50 years. The young fish were successfully migrating downstream, and their marking confirmed they had been released by the project and their size showed them to be developing healthily and appropriately at age 3-4 months. Increasing numbers of adults in the upper Rhine and tributary rivers as well as repeated proof of naturally-reproducing young shads in 2013 and 2014 indicate that the possibility of a self-sustaining and growing population of allis shad in the Rhine system seems very promising (Silva *et al.* 2015).

The second LIFE project entitled ***Conservation and restoration of the Allis shad in the Gironde and Rhine watersheds*** (LIFE09 NAT/DE/000008) is now underway, aiming to continue and to optimise the Rhine restocking measures started under the earlier project - adding an estimated 1.5-2 million larvae per year - and to identify the reasons behind the unexpected collapse of the Gironde stocks. One of the project objectives is the transfer of aquaculture techniques from France to Germany and the development of techniques to maintain an ex-situ stock in Germany. As part of these activities, a pilot ex-situ facility has been established in Aßlar in Germany. It is hoped that the further development of captive rearing and breeding techniques will eventually enable fewer shad to be removed from French rivers and to include fish returning to the Rhine system in the ex-situ stock in the future. The project is also re-examining the design of existing fish pass facilities for European allis shad, especially in France, in the light of the latest knowledge and improvements coming from the United States – where numbers of returning shads have been significantly enhanced after modernisation of the fish passes (Silva *et al.* 2015).

4.6 PUBLIC AWARENESS

4.6.1 Public awareness activities in Portugal

4.6.1.1 *World Fish Migration Day: Açude-Ponte Coimbra dam fishway, River Mondego, Portugal*

The Açude-Ponte Coimbra dam fishway is regularly visited by the public since 2014 and represents a good example of raising awareness in the general public of issues associated with the conservation of endangered migratory fish. On the 24th May 2014, the *World Fish Migration Day*, several activities were implemented in the Açude-Ponte Coimbra dam fishway. These included visits to the fishway, to the monitoring room and interaction of the public with the researchers, who presented the work developed in this infrastructure with demonstration of the methodological techniques used to monitor fishways in general, but Açude-Ponte Coimbra dam fishway in particular (Figure 4.24).

Figure 4.24. World Fish Migration Day activities in the fishway of Açude-Ponte Coimbra dam, River Mondego, Portugal. (Photos: Catarina Mateus).

4.6.1.2 ***Activities in Aquamuseum, River Minho, Portugal***

In River Minho, "Aquamuseu do Rio Minho" has been developing in the last 10 years several activities for the general public and to the local fishermen, including migratory species events (Figures 4.25 and 4.26).

Figure 4.25. Activity to the general public about migratory fish in the estuary of the river Minho. (Photo: Carlos Antunes)

Figure 4.26. Activity for fishermen and maritime authorities about *Allis shad* in the Aquamuseum laboratory. (Photos: Carlos Antunes)

4.6.2 Public awareness activities in Spain

The Hydrobiology Station "Encoro do Con", of the University of Santiago de Compostela, has conducted several events on migratory species. In 2012, within the framework of the European project MIGRANET of the Interreg IV B SUDOE (South-West Europe) Territorial Cooperation Programme (SOE2/P2/E288), two volunteer days were carried out: one in the River Ulla on July 24, 2012 and another in the River Umia on July 27, 2012 (Figure 4.27). Also within the framework of this project, an exhibition entitled "Os peixes migradores de Galicia" was established in the Municipal Auditorium of Valga (Padrón, Coruña, Spain), from 8 to 23 November 2012 (Figure 4.28).

Figure 4.27. Activities in a) River Ulla, Spain, on July 24 of 2012 and b) River Umia, Spain, on July 27 of 2012.

Figure 4.28. Exhibition entitled "Os peixes migradores de Galicia" (Migratory fish of Galicia) in the Municipal Auditorium of Valga (Padrón, Coruña, Spain).

Recently, on the *World Fish Migration Day* (on the 24th May 2014), the Hydrobiology Station "Encoro do Con" organized an informative talk on the biology of migratory fish in the Hydrobiology Station "Encoro do Con" (Vilagarcía de Arousa, Pontevedra, Spain). In the same building an exhibition of posters and pictures about the life cycles of migratory species and their ecological requirements was also installed, as well as sampling material used for the study of these species. Finally a painting workshop for primary school children was also held (Figure 4.29).

Figure 4.29. Workshop for children of primary school, held in the Hydrobiology Station "Encoro do Con", Vilagarcía de Arousa, Pontevedra, Spain.

4.6.3 Public awareness activities in Ireland

In the *World Fish Migration Day*, Inland Fisheries Ireland (IFI) organized a seminar on the topic of fish passage issues. They had guest speakers from Belgium and Northern Ireland as well as from Ireland. Dr. Jan Breine of INBO, Belgium, spoke on recovery of water quality in the Schelde and the re-appearance of twaite shad in large numbers. He also addressed issues with barriers as they relate to the shads and also to river lamprey populations.

Mr. Jake Gibson of Northern Ireland Environment Agency (NIEA) spoke on the issue of barriers and how they can impact adversely on the ecological condition of waters through preventing fish species, that should be present naturally, from being present in the water. His colleague Mr. Patrick Murphy presented a case-history of a small sub-catchment of Lough Neagh, where a rapid assessment technique identified over 500 barriers, with culverts a major problem in channels of low Stream Order and weirs a major issue in higher Stream Order channels.

Site visits were organized to see weirs and barriers presenting problems, and those where structural solutions had been implemented, in the Suir and the Nore catchments (Figure 4.30).

Figure 4.30. Delegates from Northern Ireland and Belgium with Irish hosts at rock ramp fish pass in River Nore, Kilkenny, during World Fish Migration Day events, May 2014.

The Mulkear LIFE project, with IFI as a lead partner, also organized an event for World Fish Migration Day, the family fun and learning activities focusing on the Atlantic salmon and the sea lamprey and their problems with passage at the weirs on the R. Mulkear (Figure 4.31).

Figure 4.31. World Fish Migration Day events (on the 24th May 2014) in the framework of the Mulkear LIFE project.

4.7 MAIN DIFFICULTIES

Even though there has been great effort to restore habitat connectivity and preserve lamprey and shad species, there are still a number of difficulties encountered by researchers, namely:

i) Lack of political and public awareness;

ii) Lack of coordination between administrative organs, between different parts of the river basins and between river, estuarine and marine jurisdictions;

iii) Lack of declarations by commercial fishermen in waters, or false declarations;

iv) Lack of knowledge on habitat requirements and hydromorphology of each basin;

v) Low or lack of efficiency of fishways (attractiveness, improve and adjust monitoring, improve hydraulic conditions) (Figure 4.32).

Figure 4.32. Example of two inoperable fishways in river Vouga, a Portuguese river basin where both lampreys and shads occur (Photos: Carlos Alexandre).

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