TRANS-EUROPEAN SWIMWAYS PROGRAMME

Wetlands International Europe

Trans-European Swimways Network

Wetlands International

UN environment WCMC

IUCN

WORLD FISH MIGRATION FOUNDATION

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Introduction

Migratory freshwater fishes have suffered a decline of 93% in Europe since 1970, according to the Living Planet Index report.[1] This is the highest rate for migratory fish globally. In September 2022, Wetlands International Europe (WI-EA) launched the Trans-European Swimways Network (TEN-S), in collaboration with the International Union for Conservation of Nature (IUCN), World Fish Migration Foundation (WFMF) and UNEP World Conservation Monitoring Centre (WCMC), to address the threats facing migratory freshwater fishes and to implement the Global Swimways Program[2] in Europe.

Swimways are *"rivers and their associated ecosystems that support the entire migration routes of freshwater fishes.[3]"*

The "swimways approach" builds on the lessons learnt from successes achieved within the "flyway approach" to the conservation of migratory birds. Both approaches focus on the ecological integrity of the entire range used by a migratory species during its life cycle and promote (internationally) coordinated conservation efforts at critical locations along these migratory paths. Both the flyways and the swimways approaches rely not only on a network of sites and migratory corridors, but depend on strong networks of professional and civil society organisations interacting with policy and decision-making processes at local, regional, and international levels.

In the long term, the Trans-European Swimways Programme aims to support the recovery of migratory freshwater fishes in Europe through coordinated policy and advocacy, capacity building, and field actions at critical locations. The European Green Deal, the EU Biodiversity Strategy for 2030, the proposed EU regulation on nature restoration, and the Post-2020 Global Biodiversity Framework all offer new opportunities for the conservation of migratory freshwater fishes through the swimways approach.

We aim to develop this programme together with our potential partners and stakeholders. This document contains the framework of action for the next 10 years and a situation analysis (i.e., a biological assessment, a problem analysis and an assessment of the ongoing conservation efforts).

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[1] https://worldfishmigrationfoundation.com/living-planet-index-2020/
[2] https://globalswimways.com/
[3] Worthington, T., van Soesbergen, A., Berkhuysen, A., Brink, K., Royte, J., Thieme, Mi., Wanningen, H., & Darwall, W. (2022). Global Swimways for the conservation of migratory freshwater fishes. *Frontiers in Ecology and the Environment.* 10.1002/fee.2550.

Framework for Action

This Framework for Action was created out of the Situation Analysis (see Annexes 1–5) drafted by Wetlands International Europe and planning workshop of the Trans-European Swimways Network in October 2022. It represents an ambitious long-term plan for the next 10 years. The focus is on actions that require species-specific solutions such as the conservation and restoration of habitats, the connectivity amongst them, the sustainable management of shared fish populations. Management of water quality and quantity is dealt with through the Water Programme of Wetlands

***<u>Goal:</u>* To contribute to the recovery of migratory freshwater fishes through restoring Swimways across Europe**

***<u>Purpose:</u>* To reduce the rate of decline of migratory freshwater fishes in Europe through the identification and protection of Swimways of European Importance**

International Europe.

Table 1 contains the framework for action for the Trans-European Swimways Programme, describing the problems, the related objectives, results, actions, timeframe, priorities and, potential organisations who could be responsible for their implementation if funding is secured.

Table 1. Framework for action.

Direct problem: Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes	*Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas*				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**[4]
Not all corridors for migratory fishes can be protected. There is a need for prioritisation of both restoration areas and go-to and no-go areas for transport and	Result 1.1 Swimways of European Importance (SEI) are identified and known by European,	1.1.1. Develop criteria to identify Swimways of European Importance based on the draft global Swimways criteria[5]	Essential	2023-2024	WI-EA, IUCN, WCMC, EIFAAC[6], IGB[7]
		1.1.2. Apply criteria against the existing species occurrence, economics and recreational data	Essential	2023-2024	WI-EA, IUCN FFSG[8]

[4] As this is a draft, organisations will be contacted ahead of the final version and their agreements reflected.
[5] https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.2550
[6] European Inland Fisheries and Aquaculture Advisory Commission. They have information on economic value of freshwater fisheries.
[7] Leibniz Institute of Freshwater Ecology and Inland Fisheries. They are interested in the cultural values of fish.
[8] IUCN Freshwater Fish Specialist Group

Direct problem: Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes	*Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas*				
Underlying Problems / Opportunities	Result	Action	Priority	Time scale	Potential organisations responsible[4]
hydropower development.	national and subnational decision-makers	1.1.3. Develop a network of co-authors to (a) validate the swimway biological data, (b) identify threats to the swimway, (c) opportunities for restoration and (d) act as swimway champions in the future	High	2023-2024	WI-EA, IUCN FFSG, WFMF
		1.1.4. Build a European Swimways Portal presenting the information available on the SEI in the context of other relevant data e.g. on barriers, water quality, etc.[9]	High	2024-2024	WI-EA, WCMC

[9] Possibly this Swimways Portal could be integrated into the Open River Tracker and Dam Removal Portals.

Direct problem: Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes	*Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas*				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible** [4]
	Result 1.2 30% of the migratory fishes in unfavourable conservation status are recovering and the deterioration of status is halted for the rest of them	1.2.1 Advocate the inclusion of migratory fishes in the status improvement target pledges under the EU Biodiversity Strategy	Essential	2023	WI-EA with EHF[10] partners
		1.2.2 Identify key gaps in the protected area network for migratory fishes and advocate their inclusion into the protected area pledges under the EU Biodiversity Strategy	High	2023	WI-EA, IUCN, WCMC, EAA[11]
		1.2.3 Identify key restoration opportunities for breeding or feeding habitats required for population	Medium	2024-2025	WI-EA, IUCN FFSG, IUCN, EAA

[10] European Habitats Forum
[11] European Anglers Alliance

Direct problem: **Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes**	***Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas***				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**[4]
		recovery and advocate their inclusion into the national nature restoration plans			
		1.2.4 Advocate improvements to the Water Framework Directive in respect of migratory freshwater fishes during the mid-term review of the 3rd generation of RBMPs and the discussions about the WFD	Essential	2024 - 2025	WI-EA, LRE[12]
		1.2.5 Advocate for the inclusion of relevant species and key sites during the EU accession process of countries in the Balkan and Eastern Europe	Medium	2024	WI-EA

[12] Living Rivers Europe

Direct problem: Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes	*Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas*				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible[4]**
		1.2.6 Explore opportunities under the Bern Convention to promote the swimway approach outside of the EU	Medium	2025	WI-EA
Existing barriers block lateral and longitudinal connectivity	Result 1.3 Critical barriers on SEI are identified and their removals are incorporated into the river basin management plans (RBMPs)	1.3.1. Review the status of barrier inventories in the EU and identify gaps	High	2023	WI-EA, DRE[13]
		1.3.2. Identify critical barriers impeding fish migration or reducing spawning habitats in the EU	Essential	2023-2025	WI-EA, WFMF
		1.3.3 Engage with barrier prioritization exercises to ensure that they adequately consider the needs of SEI	High	2023 ongoing	WI-EA through LRE

[13] Dam Removal Europe

Direct problem: Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes	*Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas*				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible** [4]
	and into the national nature restoration plans (NNRPs)	1.3.4 Advocate the inclusion of critical barriers into the NNRPs and RBMPs	Essential	2023 ongoing	WI-EA, LRE, EHF and national/local network partners
	Result 1.4 Impacts of unremovable barriers significantly reduced	1.4.1 Develop a policy briefing on the efficacy of fish passes and support of effective solutions.	Medium	2024	WI-EA, DRE & academic partners
		1.4.2 Work with operators of barriers in SEIs to reduce the impact of barriers	Low	2024 ongoing	WI-EA & academic partners
		1.4.3 Advocate for better fish passes and improve the monitoring of their effectiveness	Medium	2024 ongoing	WI-EA

Direct problem: **Loss of breeding/feeding habitats and connection due to river fragmentation and hydrological changes**	***Objective 1: By 2030, migratory freshwater fishes are protected in a coherent, comprehensive and well-connected network of protected areas***				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible** [4]
		1.4.4 Improve the legislation (e.g. EIA) related to permitting dams and other barriers to mitigate the impacts of barriers	**Medium**	**2024 ongoing**	**WI-EA**
New barriers are created in response to needs for hydropower, irrigation, water management and transport	**Result 1.5 Reduced river fragmentation by new barriers**	**1.5.1 Advocate for recognition of SEI as no-go areas for dams or sensitive areas for transport infrastructure**	**High**	**2023 ongoing**	**WI-EA through LRE and EHF**
		1.5.2 Engage with the legislative and permitting processes for hydropower, transport, irrigation development and flood-protection projects	**Medium**	**2023 ongoing**	**WI-EA, TEN-S**

Direct problem: Unsustainable use of some migratory fish populations	***Objective 2: By 2030, migratory fish populations are managed sustainably along international Swimways***				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**
Overfishing	**Result 2.1 Adaptive harvest management applied for selected species subject of commercial or recreational fisheries**	**2.1.1 Promote adaptive harvest management of selected species listed on Annex V of the Habitats Directive that are subject of fisheries and in unfavourable conservation status**	**Low**	**2025**	**WI-EA, EAA, EIFAAC**
		2.1.2 Promote more efficient actions against illegal fishing	**Low**	**2025**	**WI-EA, TEN-S, EEA, SEG[14]**
		2.1.3 Strengthen the implementation of the EU Eel Regulation	**Low**	**2023 ongoing**	**SEG**
		2.1.4 Influence the Common Fisheries Policy in case of diadromous species	**Low**	**2024 ongoing**	**WI-EA, SEG, WWF[15]**

[14] Sustainable Eel Group
[15] World Wildlife Fund

Direct problem: Invasive alien species	***Objective 3: Reduce the impact of invasive alien species on migratory fishes***				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**
Stocking with alien fish species	**Result 3.1 Inland fisheries cease to introduce alien species**	**3.1.1 Produce a policy brief on the use of alien species in commercial and recreational inland fisheries in the EU and its impact on migratory fishes**	**Medium**	**2025**	**WI-EA, IUCN, EAA**
		3.1.2 Collect and share best practices on managing invasive alien species	**Low**	**2026**	**WI-EA, EAA**
		3.1.3 Advocate changes to the Invasive Alien Species Regulation as necessary	**Low**	**2025**	**WI-EA, EAA**
Connecting catchments for navigation and irrigation purposes	**Result 3.2 Prevent introduction of non-native species through connecting formerly isolated catchments**	**3.2.1 Produce a review of impacts of connecting catchments on migratory fish**	**Low**	**2025**	**WI-EA, IUCN FFSG**
		3.2.2 Identify and advocate against transport and irrigation projects posing high risk of introducing alien species to SEIs	**Medium**	**2023 ongoing**	**WI-EA, TEN-S**

Direct problem: Invasive alien species	*Objective 3: Reduce the impact of invasive alien species on migratory fishes*				
Underlying Problems / Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**
Barrier removal may open up rivers or lakes for alien species leading to competition to threatened native species	Result 3.3 Barrier removal projects consider the risk of invasive alien species	3.3.1 Identify river sections with threatened migratory species currently protected from alien species by barriers. Highlight those sections on the Swimways Portal and integrate into barrier removal prioritisation exercises	Medium	2024	WI-EA, IUCN FFSG
		3.3.2 Produce guidance on assessing the risk of barrier removal on threatened species	Medium	2024	WI-EA, IUCN FFSG

Direct problem: Requirements of migratory fish often ignored in decision-making processes	***Objective 4: By 2025, a network of ambassadors for migratory fishes in at least 15 EU Member States***				
Underlying Problems/ Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**
EU legislation is poorly implemented at national, regional and local level	**Result 4.1 Increased public pressure and involvement in decision-making processes through a network of organisations forming the TEN-S**	**4.1.1 Enable national, regional and local organisations to act for migratory fish through facilitating exchange of experience and training**	**High**	**2023 ongoing**	**WI-EA**
		4.1.2 Collaborate with EAA, national and local angling associations	**High**	**2023 ongoing**	**WI-EA**
		4.1.3 Support national, regional and local organisations in challenging decisions with adverse effect on Swimways	**High**	**2023 ongoing**	**WI-EA**
		4.1.4 Increase awareness about Swimways through promoting the celebration of World Fish Migration Day, other events and producing communication materials, working with visitor centres	**High**	**2023 ongoing**	**WI-EA and members, WFMF**

Direct problem: Requirements of migratory fish often ignored in decision-making processes	***Objective 4: By 2025, a network of ambassadors for migratory fishes in at least 15 EU Member States***				
Underlying Problems/ Opportunities	**Result**	**Action**	**Priority**	**Time scale**	**Potential organisations responsible**
		4.1.5 Promote involvement of volunteers into local habitat improvement actions along Swimways	Medium	2024 ongoing	WI-EA, WFMF, TEN-S
Local actions often fail to add-up to coherent actions along Swimways	Result 4.2 Each SEI has a long-term restoration plan implemented by alliances of local stakeholders (Swimway Working Groups, SWGs)	4.2.1 Promote the establishment of SWGs for each SEI	High	2024	WI-EA, TEN-S
		4.2.2 Share good practices of swimway conservation across borders	High	2025	WI-EA with Rhine and Danube Commissions, Wadden Sea
		4.2.3 Assist SWGs for developing recovery plans for their SEIs	High	2025 ongoing	WI-EA, IUCN FFSG
		4.2.4 Work with SWG to secure large scale funding for the restoration of SEIs	Medium	2024 ongoing	WI-EA

Annex 1. Biological assessment

In this analysis, we consider only those freshwater fish species that can be classified as full migrants according to the IUCN's definition[16] that reads as follows: "*a substantial proportion of the global or regional population makes regular or seasonal cyclical movements beyond the breeding range, with predictable timing and destinations*". This definition is consistent with those proposed by other fish experts,[17,18] and it includes both diadromous (migrating between freshwater and marine waters) and potamodromous (restricted to freshwater habitats) fish species. Within the diadromous fish species, we distinguish anadromous (travel from the sea to spawn in freshwater), catadromous (travel from freshwater to spawn in the sea), estuarine (traveling from sea or freshwater to brackish water to spawn), and amphidromous (migrate either direction between saltwater and freshwater, but not for the purpose of breeding) species. The basis of our assessment is the European Red List of Freshwater Fishes (Freyhof and Brooks, 2011).[19] The migratory status was

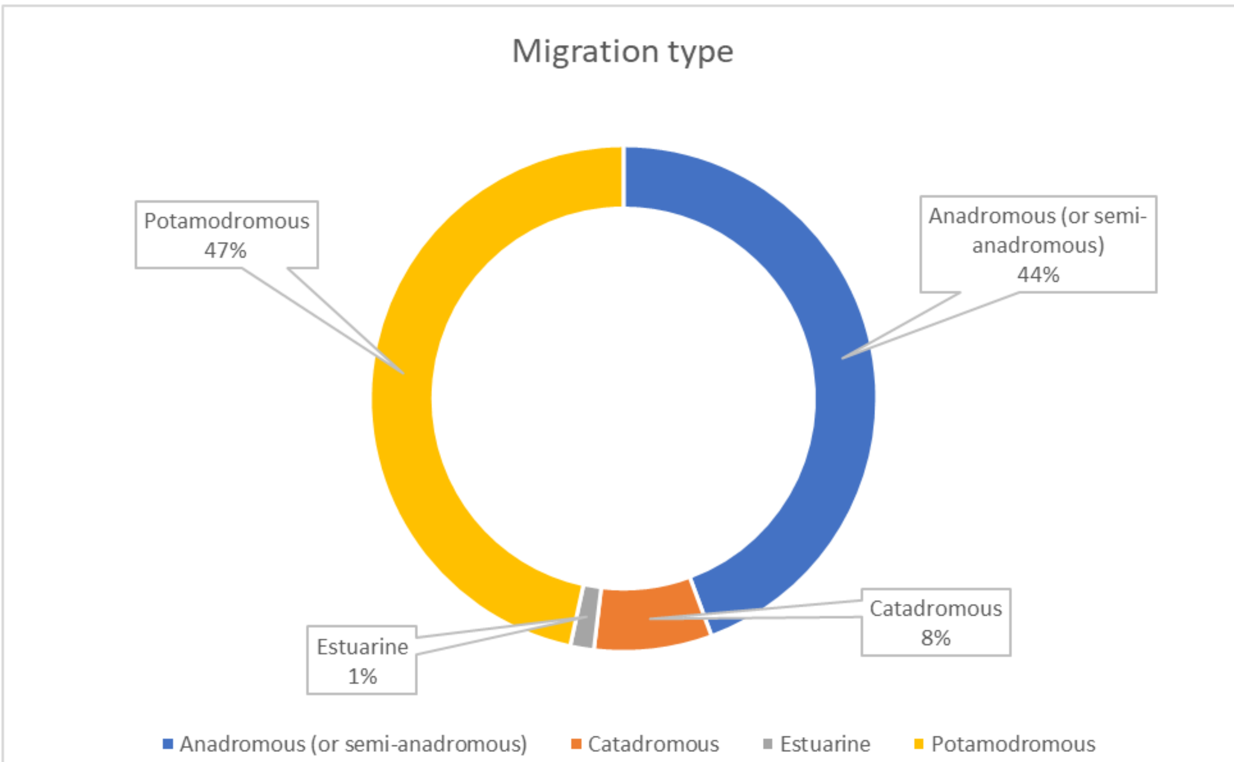

Figure 1. Percentage of migratory freshwater fish species in Europe that undertake different migration types.

[16] http://datazone.birdlife.org/species/spchabalt
[17] Northcote, T.G. (1978). Migratory strategies and production of freshwater fishes. *Ecology of Freshwater Fish Production*. John Wiley & Sons, pp. 326-359.
[18] Mcintyre, P., Reidy Liermann, C., Childress, E., Hamann, E., Hogan, D., Januchowski-Hartley, S., Koning, A., Neeson, T., Oele, D. & Pracheil, B. (2015). *Conservation of migratory fishes in freshwater ecosystems*. In book: Conservation of Freshwater Fishes Chapter: Chapter 11. Eds: Gerard P. Closs, Martin Krkosek, Julian D. Olden
[19] https://ec.europa.eu/environment/nature/conservation/species/redlist/downloads/European_freshwater_fishes.pdf

classified based on IUCN Red List factsheets,[20] the Handbook of European Freshwater Fishes (Kottelat & Freyhof, 2007) and consultation with other sources and experts.

Of the 538 European freshwater species in our dataset, we consider 136 to be migratory. 56 of them are anadromous, 10 are catadromous, 2 estuarine, and 68 potamodromous (Figure 1). 96 of the 136 European migratory freshwater fish occur in the European Union.

Most migratory freshwater fish species occur in the Continental biogeographic region, followed by the Steppic, Mediterranean, Alpine, Black Sea, Boreal, Atlantic, Pannonian, Arctic and Anatolian regions (Figure 2, Figure 3). The Volga, Don, Dnieper, Danube and Rhine rivers and their tributaries emerge as particularly important for many migratory freshwater fishes. However, a number of populations are already extinct or impoverished in these highly regulated rivers.

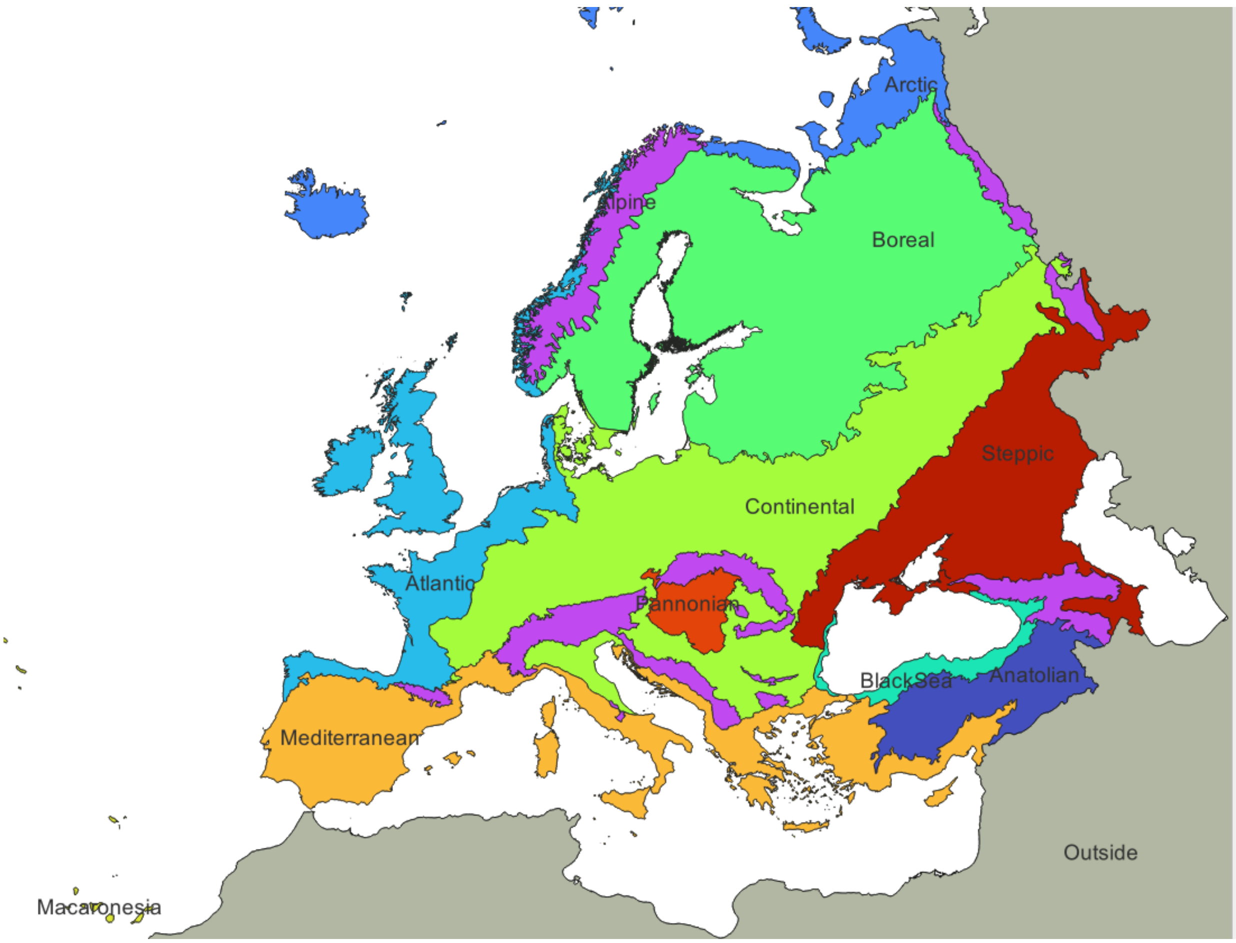

Figure 2. Biogeographic regions in Europe used in this document.[21]

[20] https://www.iucnredlist.org/search?permalink=f00e8ef7-9f9a-48a5-abca-4ba0bb1cab8f
[21] European Environment Agency (EEA) 2016

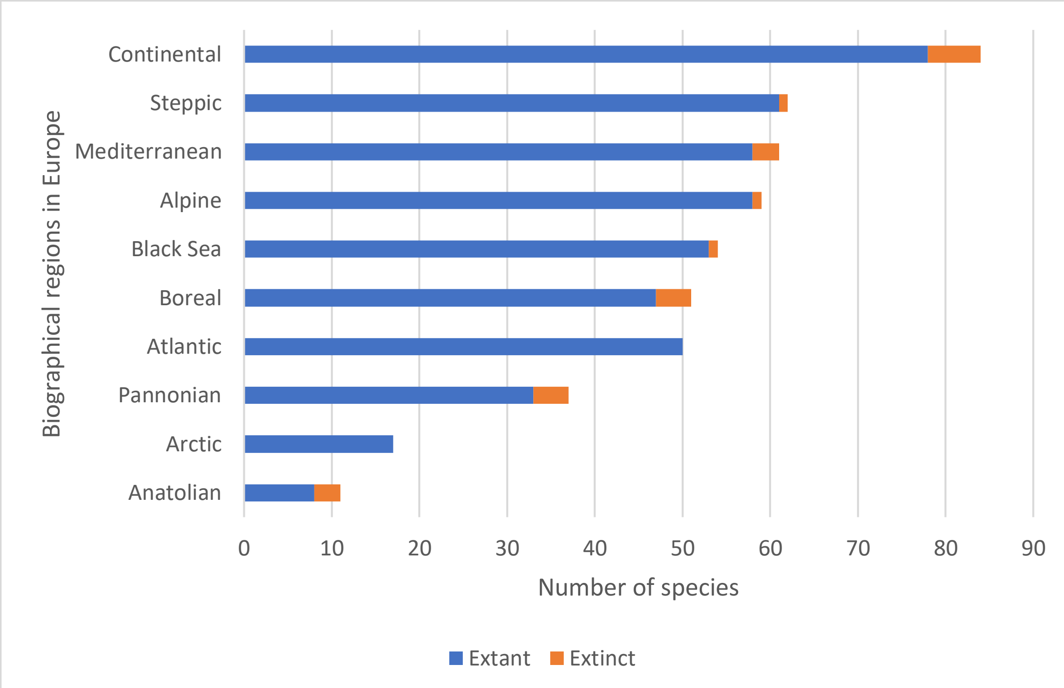

Figure 3. The number of migratory freshwater fish species by biogeographic region In Europe.

The Living Planet Index shows a 93% decline in the populations of migratory freshwater fishes based on 408 local populations of 49 species between 1970 and 2016 (Figure 4).

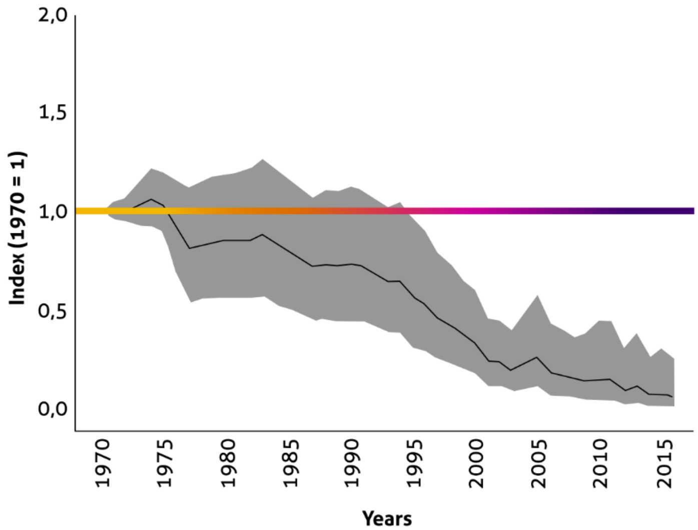

Figure 4. Average change in abundance of monitored migratory freshwater fishes (GROMS-listed as anadromous, catadromous, amphidromous, diadromous or potamodromous) between 1970 and 2016 in Europe (-93%; 408 populations of 49 species.[22]

Based on IUCN Red List data, 75% of extant migratory freshwater fish species with a known population trend are declining in Europe. Many species are suffering range contractions. Five species are extinct or extinct in the wild in Europe and two in the European Union. 36 species (26%) are Threatened and three (2%) are Near Threatened in Europe, while 29 species (30%) are Threatened, and one species (1%) is Near Threatened in the EU.

44 (32%) of the migratory freshwater fish species are listed in the annexes of the EU Habitats Directive. A vast majority of migratory freshwater species have unfavourable conservation status in most of the biogeographic regions (Figure 5).[23]

[22]Deinet, S., *et al.* (2020). The Living Planet Index (LPI) for migratory freshwater fish - Technical Report. World Fish Migration Foundation, The Netherlands.
[23] Nine of the migratory freshwater fish species listed in the annexes of the Habitats Directive have no assessment under the Article 17 reporting for the period of 2013–2018. For 7 of the 13 diadromous species listed in the annexes of the Habitats Directive, there is no assessment for the marine phase of their life cycle.

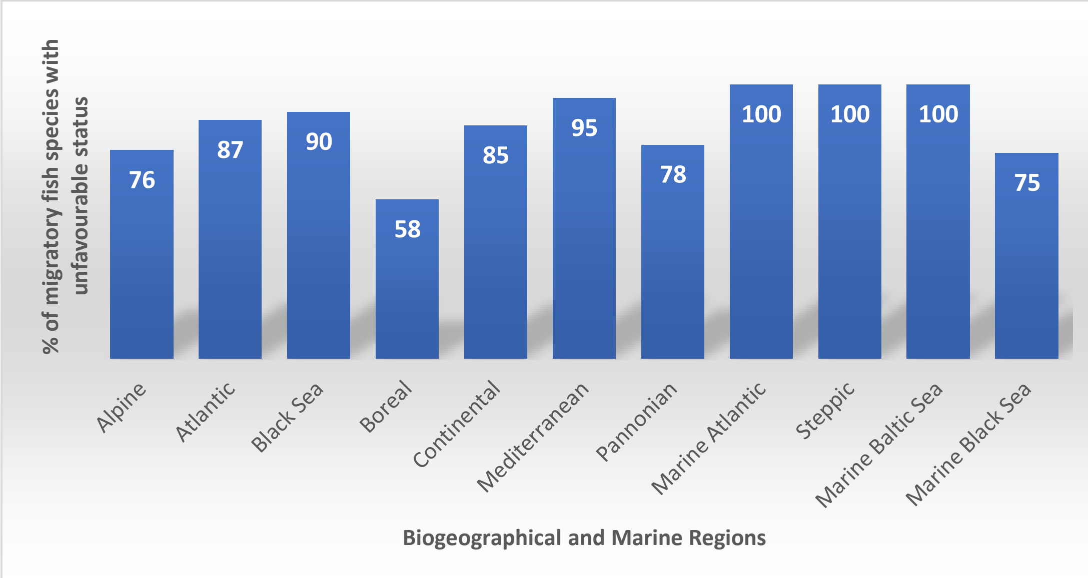

Figure 5. Percentage of migratory freshwater fish species listed in the annexes of the Habitats Directive assessed as having unfavourable conservation status in the 2013 – 2018 reporting period by biogeographic region.

Annex 2. Problem Analysis

As the previous chapter shows, migratory freshwater fishes are severely threatened in Europe. Based on the IUCN Red List threat assessments for 73 species, the main threats are dams, intentional and unintentional effects of fishing, pollution, groundwater abstraction, invasive alien species and climate change (Figure 6).

Reporting EU Member States indicate a similar pattern for the 44 migratory fish species assessed under Article 17 of the Habitats Directive (Figure 7). Hydropower, pollution, modification of hydrological flows, over-fishing, abstraction of water, and invasive alien species feature among the most frequently mentioned pressures and threats.

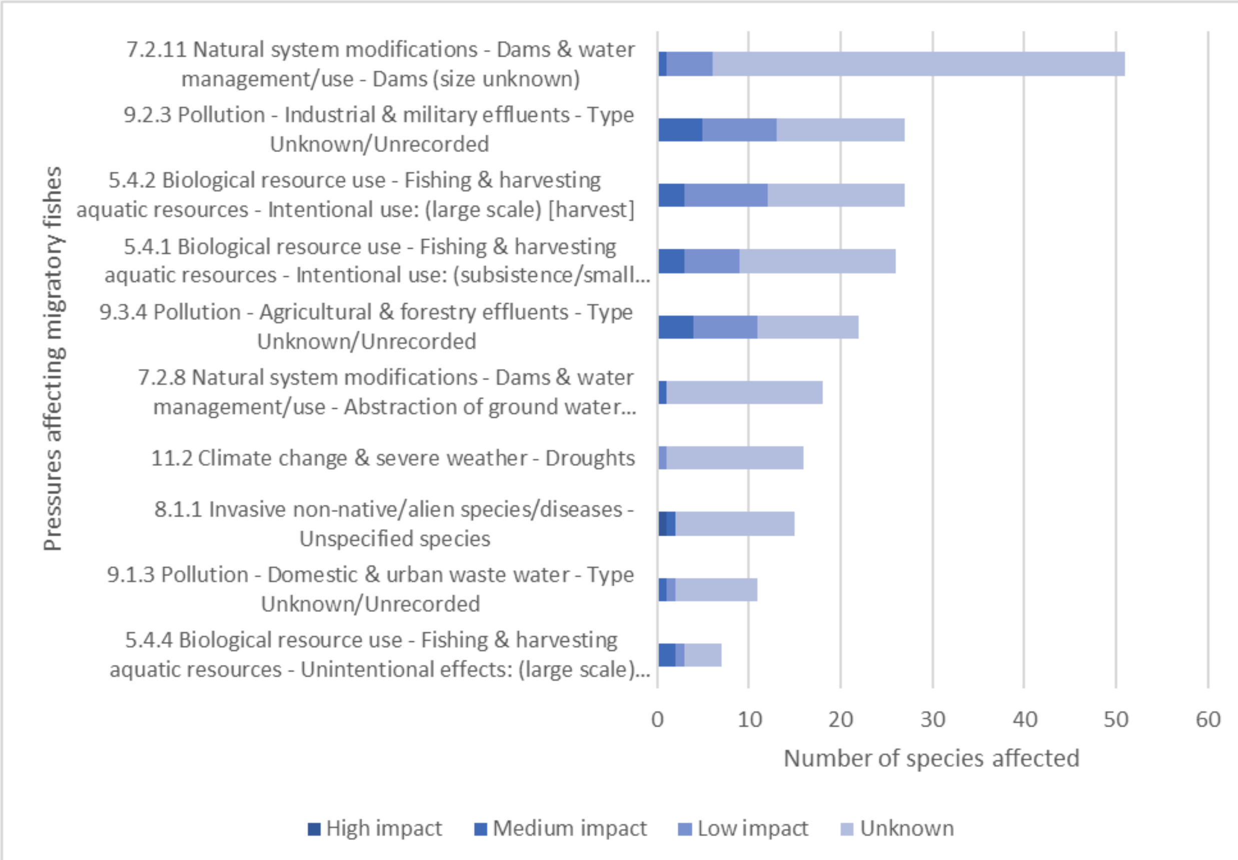

Figure 6. Threats affecting migratory freshwater fishes based on the IUCN Red List threat assessments.[24]

[24] **See details of the categories in the IUCN Threat Classification Scheme at** https://nc.iucnredlist.org/redlist/content/attachment_files/dec_2012_guidance_threats_classification_scheme.pdf

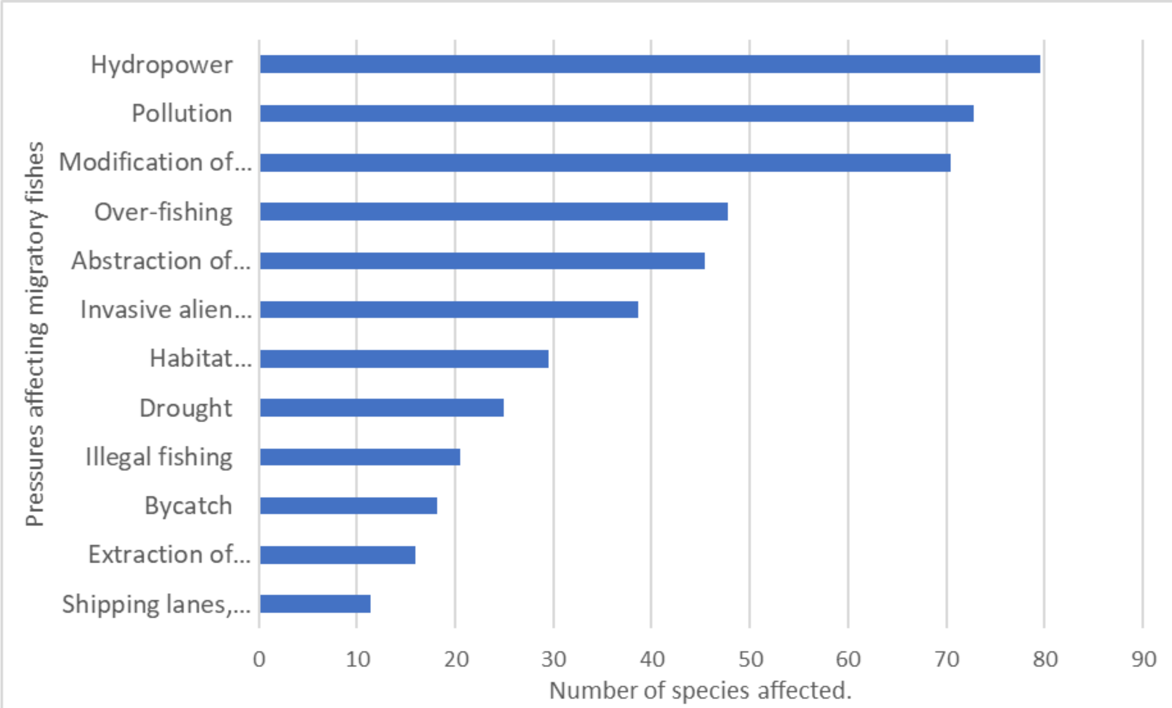

Figure 7. Pressures and threats affecting migratory freshwater fishes based on Member States reporting under Article 17 of the EU Habitats Directive.

Migration Barriers

Dams affect 70% of the assessed migratory freshwater fish species (Figure 6). Hydropower is the most frequently mentioned pressure and threat for these species mentioned in EU Member States reports under Article 17 of the Habitats Directive and modification of hydrological flows is the third most frequently mentioned (Figure 7).

Dams and other barriers cause river fragmentation, change hydrological and temperature regimes, lead to habitat changes, and increase direct mortality of fish and eggs. River fragmentation is the main factor in the decline of migratory freshwater fish species in Europe. These barriers impact both the longitudinal (upstream/downstream) and lateral (between rivers and their floodplains) movements of fish.[25] Freshwater fish population declines in Europe are estimated to be caused by dams and weirs in 55-60% of cases.[26]

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[25] Drouineau H, Carter C, Rambonilaza M, et al. (2018). River continuity restoration and diadromous fishes: much more than an ecological issue. *Environ Manage* 61: 671–86.
[26] Birnie-Gauvin, K., Aarestrup,K., Riis,T.M.O., Jepsen,N. & Koed,A. (2017). Shining a light on the loss of rheophilic fish habitat in lowland rivers as a forgotten consequence of barriers, and its implications for management. *Aquatic Conserv: Mar Freshw Ecosyst.*;1–5.

Besides dams, other types of barriers include weirs, sluices, culverts, fords, and ramps. Dams and weirs on high-energy rivers can be the most damaging to fish as they affect the habitat and water flow regime.[27] The specific impacts of these barriers include channel blocking, ponding, changes in channel morphology, flow regulation, and changes in water velocity as well as silting and changes in water quality. For culverts, fish passages can be impacted by higher water velocities, low water depth, lack of shelter, high outflows and debris jams,[28] as well as by altering the transport of sediment and organic material.

Dams and other types of barriers are built to generate hydropower, water storage for agriculture, industry and human consumption, navigation, and flood protection.

There are over 1.2 million longitudinal barriers on rivers in Europe, and Dam Removal Europe estimates that there is almost one barrier for each kilometre of river.[29] Data from the Adaptive Management of Barriers in European Rivers (AMBER) indicates that less than 3% of these barriers are higher than 10 metres, thus small dams are much more prevalent.[30] While no exact figure of the total number of barriers exists, it is estimated that about 10% of them are obsolete in Europe[31] and create an unnecessary blockage in the habitat.

Embankments, and water regulation structures like inlet and outlet sluices obstruct the lateral connectivity of rivers and make the use of banks inaccessible for fish to use for refuges, nurseries, or sites for juvenile development.

Hydropower plant turbines present a high mortality obstacle for fish when they migrate downstream, especially for salmon smolts and adult eels. Passing through a turbine causes various forms of stress which leads to high mortality. Stresses include speed strike when going through the different parts of the turbine, sudden acceleration and deceleration, and very sudden variations in pressure. Mortality rates vary from one fish to another but are typically higher in fish that regulate pressure slowly, as the risk of rupturing the swim bladder is higher. The mortality rate in adult eels is generally higher because of their length.

As dams and hydropower plants are built to produce hydro-energy, in Europe this is regulated by the Renewable Energy Directive which provides the legal framework for development of renewable energy across all sectors of the EU economy. On 18 May 2022, the European Commission published the REPowerEU plan, which sets out a series of measures to reduce the dependence on fossil fuel from Russia.[32] It includes

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[27] AMBER Consortium (2020). Impacts of Barriers on Biodiversity of Running Waters. AMBER Policy Brief No 3., 14 pp. https://amber.international/policy-briefs/

[28] Kemp & Williams (2008). Response of migrating Chinook salmon (Oncorhynchus tshawytscha) smolts to in-stream structure associated with culverts. *River Research and Applications* 24(5), 571-579.

[29] Gough, P., Fernández Garrido, P., & Van Herk, J. (2018). Dam Removal. A viable solution for the future of our European rivers. Dam Removal Europe.

[30] AMBER (2018). https://amber.international/

[31] European Environment Agency. (2021). Many obsolete barriers harm Europe's rivers. EEA, https://www.eea.europa.eu/highlights/many-obsolete-barriers-harm-europes-rivers

[32] European Commission. (2022). REPowerEU plan. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en

the proposal to further amend the EU Renewable Energy Directive (RED). While it does not include specific initiatives related to hydropower, nor does it exclude it. A number of Member States are now announcing new hydropower projects or trying to reintroduce some controversial ones.[33]

Another reason for river obstructions is to facilitate inland water transport. This is also encouraged by the EU, as it is a competitive alternative to road and rail transport. The TEN-T (Trans European Transport Network) policy addresses "the implementation and development of a Europe-wide network of railway lines, roads, inland waterways, maritime shipping routes, ports, airports and railroad terminals".[34] The ultimate goal of this project is to strengthen social, economic and territorial cohesion in the EU. The TEN-T aims to facilitate the mobility of goods and passengers within the EU on the 41,000 km of navigable inland waterways.

Pollution

Pollution of industrial & military effluents affects 37% of migratory freshwater fishes in Europe, agricultural and forestry effluents affect 30%, and domestic and urban wastewater affect 15%, according to the IUCN Red List threat assessments (Figure 6). Pollution is also the second most frequently mentioned pressure and threat reported by the EU Member States in their reporting under Article 17 of the Habitats Directive (Figure 7). Figure 8 demonstrates the geographic widespread problem in Europe, displaying river basin districts with less than good ecological status as of 2015. Hazardous substances in aquatic systems can be inorganic, such as metals like cadmium and mercury, or organic, such as pesticides, pharmaceuticals, hormones, antibodies and PAH.

[33] EEA, EEB, ERN, Wetlands International, WWF. (2022). REPowerEU revision of the Renewable Energy Directive and hydropower. Briefing paper.
[34] https://ec.europa.eu/inea/en/ten-t/ten-t-projects

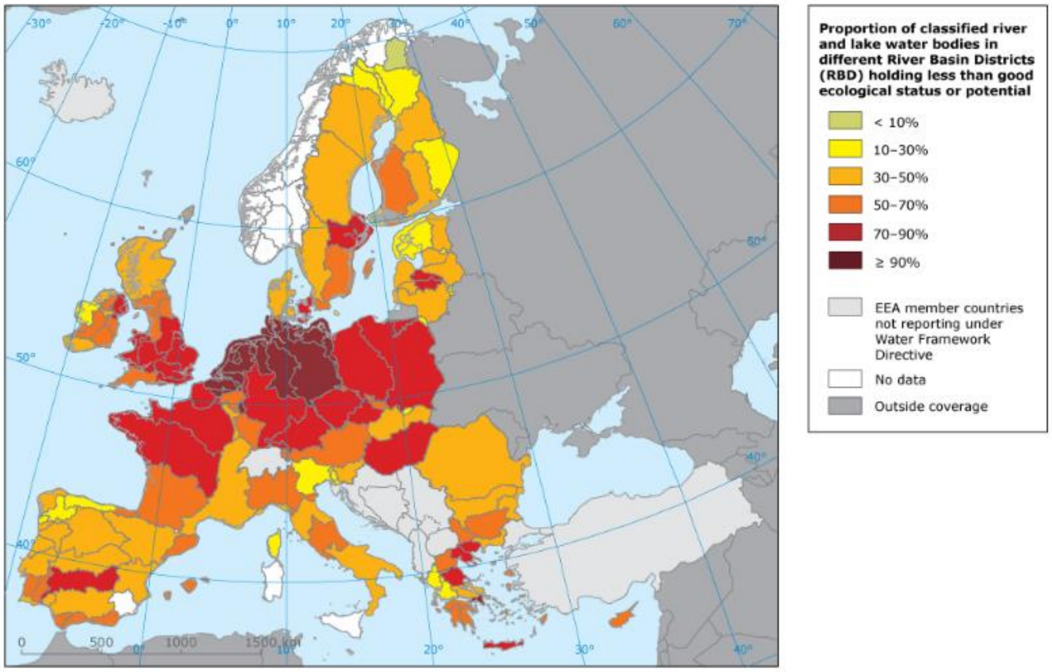

Figure 8. Proportion of classified river and lake water bodies in River Basin Districts with less than good ecological status or potential. While the less than good status reflects more than just pollution, it is a good indication of the spatial distribution of the problem.[35]

Large amounts of such pollutants can cause immediate fish mortality, whereas smaller amounts can have long-term impacts such as the accumulation of contaminants in fish. Since fishes are typically highly sensitive to small quantities of metals, they are often a good indicator of genotoxic toxins in aquatic systems. Suppressed immune responses, reduction of metabolism, harm to gills and other body parts are some of the possible effects, and diseases include fin rot, tail rot, gill disease, damaged hepatic tissues and ulceration.[36]

Pollutants and variations in water temperature can cause significant behavioural changes in migrating fishes, as they are usually unable to take behavioural avoidance measures. Impacts can include adverse changes to swimming performance, homing ability, predator avoidance, sexual and sociability aggressiveness, foraging and spawning site selection.[37], as presented in Table 2. The linkage among pollutants and behaviour in fish species. Murky water from high levels of suspended solids can reduce the sight of fish, making predation more difficult. A study conducted on the Eems canal in the Netherlands showed that temperature increases driven by discharge

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[35]European Environment Agency (EEA) WISE WFD Database 2015; https://www.eea.europa.eu/soer/2015/europe/freshwater
[36] Malik, D., Sharma, A., Sharma, A., Thakur, R. & Sharma, M. (2020). A review on impact of water pollution on freshwater fish species and their aquatic environment. 10.26832/aesa-2020-aepm-02.
[37] Brink, K., P. Gough, J. Royte, P.P. Schollema & H. Wanningen. (2018). From Sea to Source 2.0. Protection and restoration of fish migration in rivers worldwide. World Fish Migration Foundation.

from a water treatment plant likely influenced eels' movements.[38] Changes in the oxygen levels in river basins, such as low oxygen content or hypoxia, can disrupt migrations through delaying river entry by diadromous fish.[39] The decreased light, increased TSS and settling material from low oxygenation can also result in fish mortality. Salmon species such as Atlantic Salmon (*Salmo salar)* and Atlantic Trout (*Salmo trutta)* are especially susceptible as they require high amounts of dissolved oxygen. A 2013 study of Atlantic salmon showed that aluminium contamination caused reduced spatial memory and learning capacity, which are important for managing new environments.[40]

Table 2. The linkage among pollutants and behaviour in fish species

Contaminant	Fish species	Behavioural traits	MS	S	V	Source
Fluoxetine	Several fish species	Antipredator behaviour, boldness, aggression, associative learning	Yes	Yes	No	Dzieweczynski *et al* (2016); Eisenreich *et al.* (2017); Martin *et al.* (2017); Saaristo *et al.* (2017)
Oxazepam	*Salmo salar*	Migration	Yes	No	No	Hellstrom *et al.* (2016); Klaminder *et al.* (2019)
Carbaryl, chlordane, 2,4 DMA, DEF, Methyl parathion, pentachlorophenol	*Oncorhynchus mykiss*	Activity, feeding	Yes	No	No	Little *et al.* (1990)
Mercury	*Danio rerio*	Activity, escape	Yes	No	No	Weber (2006)
Methylmercury MeHg	*Fundulus heteroclitus*	Sociality	No	No	Yes	Ososkov and Weis (1996)

MS: multi-stress; S: syndrome; V: variability.

Pesticides pose serious threats to the integrity of aquatic ecosystems and food webs. Used in agriculture, they contaminate many waters providing habitat for endangered fish species. Pesticides are toxic to the primary producers of the food web, such as algae and macroinvertebrates. By disrupting the food web, pesticides can have major indirect impacts on aquatic habitats and fish species. As a response, the Water Framework Directive aims to protect water quality from pesticide pollution. However, over 400 different active pesticide substances are still approved in the EU. A recent

[38] Foekema, E. et al., (2011). Vismigratie en lozingspluimen: Samenvattend rapport, Wageningen: Institute for Marine Resources & Ecosystem Studies.
[39] Lucas, M. C. et al., (2001). Migration of Freshwater Fishes. London: Blackwell Science Ltd.
[40] Grassie, C., Braithwaite, V.A., Nilsson, J., Nilsen, T.O., Teien, H.C., Handeland, S.O., Stefansson, S.O., Tronci, V., Gorissen, M., Flik, G. and Ebbesson, L.O.E. (2013). Aluminium exposure impacts brain plasticity and behaviour in Atlantic salmon (*Salmo s*alar). *Journal of Experimental Biology*, 216: 3148–3155.

study in Spain found that Spanish river basins are widely contaminated with toxic substances, including pesticides from agriculture.[41]

Hydroelectric dams can lead to poor water quality downstream of the structures such as changes in water temperature, anoxia, dissolved gas supersaturation, heightened levels of hydrogen sulphide and reduced productivity.[42] These conditions may also increase the solubility of iron, manganese and heavy metals. Thermal changes of the water brought about by dams has been shown to significantly impact reproduction, growth, distribution, and assemblage of fish downstream.[43]

Inland navigation and transportation can also negatively impact the water quality of rivers and the ecology there. Shipping operations can discharge pollutants such as mineral oil and lubricants, heavy metals, organic substances (PAH), and have the potential for larger oil spills.[44]

In some rivers, fishing for human consumption has ceased due to pollution there. On the Rhone River in France, high pollutants such as PCB have been causing problems to the ecosystems there since the 1980s, leading the French government to ban the consumption of fish caught on the river in 2007.[45] Another example is in the North Rhine-Westphalian catchment of Germany, where high pollution levels found in European eels there have made them no longer suitable for consumption.[46]

Fishing

Large-scale fishing affects 37%, small-scale fishing 36% and side effects of large-scale fishing affects 10% of the assessed migratory freshwater fish species in Europe according to the IUCN Red List threat assessments (Figure 6). Overfishing is the fourth most frequently mentioned pressure and threat by the EU Member States in the Habitats Directive Article 17 reporting (Figure 7).

Overharvesting of fishes for human consumption and more often for commercial purposes, continues to be a major threat affecting migratory fishes in Europe. Certain species such as sturgeons, eel and salmon are particularly targeted by fishers.

[41] Hernández, K. and García, K. (2022). Ríos tóxicos. Contaminación química de ríos y aguas subterráneas. *Ecologistat en Acción.*
[42] Olden, J.D. (2015). Challenges and opportunities for fish conservation in dam-impacted waters, in Closs, G., Krkosek, M., & Olden, J. (Eds.) *Conservation of Freshwater Fishes.* Cambridge: Cambridge University Press.
[43] Haxton, T.J., and Findlay, C.S. (2008). Meta-analysis of the impacts of water management on aquatic communities. *Canadian Journal of Fisheries and Aquatic Sciences,* 65; 437-447.
[44] Deltares (2013). Diffuse water emissions in E-PRTR.
[45] PCB Polluted Rhone, France. (2018). *Environmental Justic Atlas.* https://www.ejatlas.org/conflict/polluted-rhone-france
[46] Guhl, B., Stürenberg, FJ. & Santora, G. (2014). Contaminant levels in the European eel (*Anguilla anguilla*) in North Rhine-Westphalian rivers. *Environ Sci Eur* 26, 26.

Contrary to marine fisheries, freshwater fisheries are not subject of the EU Common Fisheries Policy except some support to aquaculture developments. Commercial fisheries in freshwater are rare in Europe and there is limited available data. Globally, there is an important discrepancy between data on marine fisheries and freshwater fisheries.

Fishery management plans (FMP) are implemented in European freshwaters by national or regional administrations. For instance, in March 2022, the final draft for the Lough Neagh Fishery Management Plan was published for a lake in Northern Ireland. The Department of Agriculture, Environment and Rural Affairs (DAERA) conducted extensive research on biological synopsis, stocks assessment and genetics, taking into account threats such as stocking and invasive species. The FMP aims to address fishery management issues such as legislation, governance, development, conservation and lack of scientific data. The plan concludes with 27 proposals to address the issues previously mentioned, including to halt the use of finer twines in the construction of nets, limit the length of nets that can be used in the lake, and the introduction of a single licence for anglers.[47]

There is a distinction between commercial and recreational fisheries; commercial fishing refers to "the harvesting of fish, either in whole or in part, for sale, barter or trade",[48] whereas 'recreational fisheries' refers to non-commercial fishing activities exploiting biological resources for recreation, tourism or sport.[49] Recreational fishing still generates economic profits: it supports hundreds of thousands of jobs – including 37,000 in England and Wales and 4,300 jobs in Scotland – and provides over US$1.3 billion to the English and Welsh economies.[50] It should be noted that the Common Fisheries Policy does not define recreational fisheries.

Recreational fisheries rely on healthy freshwater ecosystems, and as such, they often participate in conservation efforts. For instance, the hump-backed mahseer (an Indian fish) was close to extinction in 2015 when international scientists realised the danger of decline for this freshwater mega-fish thanks to the detailed catch-log books kept by angling camps.[51] Recreational fishing is not a threat to freshwater fish species as such, but problems arise when it is poorly managed, when anglers do not handle and release fishes correctly, or when species are introduced in a different place. For instance, recreational fishing is slowing the recovery of the Pike-perch (*Sadner lucioperca*) and Eurasian perch (*Perca fluviatilis*) in the Kaunas Reservoir of Lithuania, which also has major impacts on the food web. The study by Dainys, J. *et al.*

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[47] DAERA.(2022). Lough Neagh Fishery Management Plan. https://www.daera-ni.gov.uk/sites/default/files/publications/daera/IFG%20-%20Lough%20Neagh%20Fishery%20Management%20Plan%20-%20Final%20draft%20March%202022.pdf

[48] OECD. (1998). Review of Fisheries in OECD Countries: Glossary.

[49] Regulation (EU) 2017/1004 of the European Parliament and of the Council of 17 May 2017 on the establishment of a Union framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the common fisheries policy and repealing Council Regulation (EC) No 199/2008

[50] Mawle, G.W., Peirson, G. (2009). Economic evaluation of inland fisheries. *Environment Agency.* ISBN: 978-1-84432-975-5.

[51] Hughes, K. (2021). The World's forgotten fishes. *WWF.* https://wwfint.awsassets.panda.org/downloads/world_s_forgotten_fishes__report_final__1.pdf

demonstrated that "recreational fishing can have strong and selective impacts on fish species, reduce predator abundance, alter relative species composition and potentially change ecosystem state and dynamics".[52]

Illegal fishing is another grave threat to many freshwater fishes. Illegal, Unreported and Unregulated (IUU) fishing threatens ecosystems, fish stocks and the people relying on them. The EU recognises the importance of tackling IUU fishing within the IUU regulation (which entered into force on 1 January 2010) that aims to prevent, deter and eliminate IUU fishing. This regulation only applies to fishing vessels in maritime waters and leaves out illegal fishing in freshwaters. However, many freshwater fishes are threatened by illegal fishing, including sturgeons for illegal wild caviar and European eels. In the UK, 2 829 incidents of fisheries crime were reported in 2021, leading to 816 convictions. Those incidents include rod fishing, salmon sea trout and trout poaching, eel and elver fishing or export and acts of theft (stealing of fish from private waters).[53]

A cause of illegal fishing in Europe is insufficient regulations and enforcement. A 2018 OECD report determined that globally, efforts to combat IUU fishing are not sufficient, and more than 15% of global fish capture is taken illegally.[54] In Europe, such efforts include advocating for its criminalization in Norway, and administrative sanctions such as criminal sanctions in Member States of the EU. There was a debate as to whether the European Commission would include IUU fishing in its list of environmental crimes in the revised Environmental Crime Directive, however, this was not included in their 2021 regulation proposal.[54] The original 2008 Environmental Crime Directive has faced implementation challenges within Member States such as a lack of resources, intelligence data to design prevention strategies for detection and prosecution and environmental law enforcement agencies.[54] A 2017 report from the European Commission states that an area with one of the biggest shortcomings is enforcement of EU regulations around IUU, especially concerning sanctions, point system and follow up of infringements.[55] It notes that some of the worst enforcement records come from France, Finland and Germany. The Commission's findings are in line with those of ClientEarth, whose analysis also concluded that the EU fisheries law is not being properly enforced and fines for IUU fishing are rare.[55]

Invasive Alien Species

[52] Dainys, J.; Jakubaviciute, E.; Gorfine, H.; Kirka, M.; Rakleviciute, A.; Morkvenas, A.; Putys, Ž.; Ložys, L.; Audzijonyte, A. (2022). Impacts of Recreational Angling on Fish Population Recovery after a Commercial Fishing Ban. *Fishes* 2022, 7, 232. https://doi.org/10.3390/ fishes7050232
[53] https://www.wcl.org.uk/docs/assets/uploads/WCL_Wildlife_Crime_Report_2021_29.11.22.pdf
[54] Fajardo, T. (2022) To criminalise or not to criminalise IUU fishing: The EU's choice. *Marine Policy*,144,105212.
[55] ClientEarth. (2017) Commission warns lack of enforcement is undermining EU fisheries law. https://www.clientearth.org/latest/latest-updates/news/commission-warns-lack-of-enforcement-is-undermining-eu-fisheries-law/

Species invasion is a major threat to European rivers' biodiversity and is among the most important reasons for declines of native fish populations. Invasive alien species affect 21% of the assessed migratory freshwater fish species in Europe according to the IUCN Red List threat assessments (Figure 6). It is also a frequently mentioned pressure and threat by the EU Member States in the Habitats Directive Article 17 reporting.

Non-native fish species and invasive alien species can have adverse impacts on local species through increasing competition and altering competition dominance, increasing predation rates and reducing reproductive success, as well as increasing the virulence of diseases. A 2017 study of the changes to European freshwater fish biodiversity demonstrated that introduced species contributed significantly to taxonomic change of freshwater ecosystems.[56]

Non-native fish species are not necessarily invasive. A non-native species has the ability to survive in a different habitat than the one of origin, but becomes invasive when it presents the two following traits: rapid growth and ability to disperse, and an absence of predators in the invaded habitat. They can be introduced accidentally or deliberately into a natural environment. In Europe, they represent a major threat to native plants and animals, and cause damage worth billions of Euros to the European economy every year.[57] In France, more than 40 freshwater alien species have been either voluntary or involuntary introduced in the past decades.[58] Motives for voluntary introduction are mainly aquaculture, ornament, and sport fishing (deliberate stocking of alien species). The two most common non-native species in Europe are the Common carp (*Cyprinus carpio*) and the Rainbow trout (*Oncorhynchus mykiss*) due to aquaculture.[59] Involuntary introduction may occur because of contaminated shipping or aquarium trade.

As a result, conservation groups may have difficulty getting the licence for barrier easement options when invasive species are present in some countries. For example, major projects for barrier removal have been held up in Scotland for this reason.

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[56] Sommerwerk, N., Wolter, C., Freyhof, J. & Tockner, K. (2017). Components and drivers of change in European freshwater fish faunas. *Journal of Biogeography* 44(8); 1781-1790. 10.1111/jbi.13019

[57] https://ec.europa.eu/environment/nature/invasivealien/index_en.htm

[58] Teletchea, F., & Beisel, J. (2018). Alien Fish Species in France with Emphasis on the Recent Invasion of Gobies. In (Ed.), Biological Resources of Water. IntechOpen. https://doi.org/10.5772/intechopen.73408

[59] Elvira, B. (2001). Identification of non-native freshwater fishes established in Europe and assessment of their potential threats to the biological diversity. *Convention on the Conservation of European Wildlife and Natural Habitats.*

Water Abstraction

Ground water abstraction affects 21% of the assessed migratory freshwater fish species in Europe according to the IUCN Red List threat assessments (Figure 6). Abstraction of water is also the fifth most frequently mentioned pressure and threat by the EU Member States in the Habitats Directive Article 17 reporting (Figure 7).

Research has shown that relationships exist between river flow and fish diversity,[60] demonstrating a clear link between a healthy river level and the sustenance of native fish populations. Water abstraction from riverine systems, either directly from the river or more commonly from the groundwater that feeds into the river basin, directly impacts the available flows of surface water (Figure 9). Practices of abstraction have been occurring for centuries across Europe, but recently it has become more intensive due to increased demand from growing populations and an increasing trend of drought during summer months. Abstracted water can be used for drinking water, industry, irrigation, or recreation.

Alterations of the natural flow regime can have significant effects on migratory fish species in freshwater rivers and lakes, particularly if so much water is removed that it is classified as over-abstraction. This refers to removing more water than the river can tolerate, reducing it to unacceptable conditions. The impacts of over abstraction can include; alterations to flow regime, alterations in river chemistry (increasing temperature, pH, decreasing dissolved oxygen), increasing sediment deposition (causing reduced spawning habitats), increased risk of invasive species establishment, decreasing water depth (making barriers more impassable), reduced connectivity to floodplains, and increased risk of entrainment by eggs or young fish at abstraction points. Another effect of abstraction is direct mortality of fishes at intakes.

[60] Muneepeerakul, R., Bertuzzo, E., Lynch, H., Fagan W.F. and Rinaldo A., (2008). Neutral Metacommunity models predict fish diversity patterns in Mississippi-Missouri basin. *Nature*, 453: 220-222.

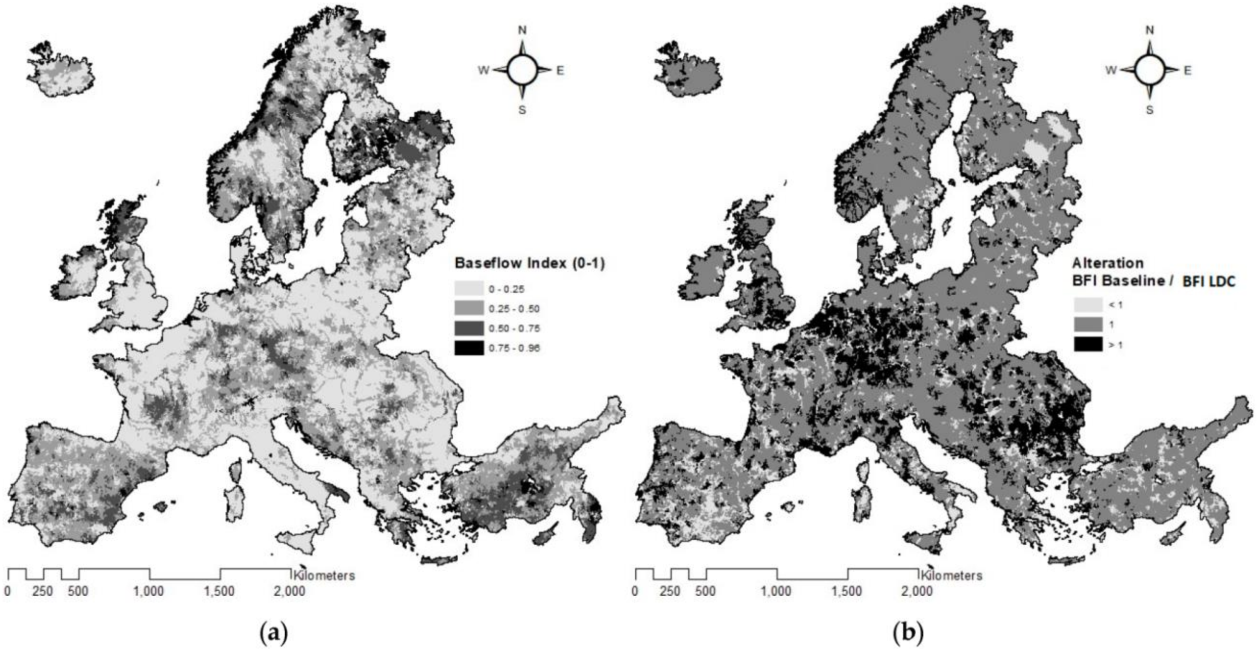

Figure 9. a) Baseflow index (BFI) of the 10-y period under the least disturbed conditions (LDC) scenario, i.e., the scenario of the historic climate 2001–2010 with the LDC. BFI is defined as the 7-day minimum flow/mean annual flow of the year. (b) Alteration of the BFI from the least disturbed conditions, expressed as BFI (baseline)/BFI (LDC). Ratios below unity indicate decrease in BFI due to abstractions, values equal to unity show no alteration and values above unity show increase from the least disturbed conditions. Reduction is depicted on the right map with lighter colors and is observed mostly in parts of the Mediterranean countries. Increase in BFI (ratio > 1) is found in Central and Eastern Europe. Very large parts all across the continent and especially in the North remain unaltered with respect to BFI (ratio = 1).[61]

Abstraction becomes even more problematic when it is done illegally, which is more and more common in places like the Mediterranean, the Black Sea, and the Caspian Sea. Illegal abstractions are abstractions exceeding the legal authorised quantities or undeclared and unauthorised ones. For instance, Spanish authorities estimate that about 510,000 illegal wells exist in Spain, extracting at least 3,600hm^3 of water as opposed to legal abstractions of 4.500hm^3.[62] Thus, about 45% of all Spanish aquifers are abstracted from without legal constraints. Furthermore, River Basin Management Plans usually do not account for illegal water abstraction, and sometimes overestimate water return rates.

Migratory fish species are adapted to specific water currents and flows. Thus, when these flows change, it can impact fish migration. The difference between ecological and environmental flow is fundamental: while environmental flow refers to the minimum supporting flow required for ecosystems and economic activities (i.e. quantity of water), ecological flow ensures the conservation of river basins

[61] Panagopoulos, Yiannis, Kostas Stefanidis, Marta Faneca Sanchez, Frederiek Sperna Weiland, Rens Van Beek, Markus Venohr, Lidija Globevnik, Maria Mimikou, and Sebastian Birk. 2019. "Pan-European Calculation of Hydrologic Stress Metrics in Rivers: A First Assessment with Potential Connections to Ecological Status" Water 11, no. 4: 703.
[62] WWF. (2006). Illegal water use in Spain. Causes, effects and solutions. https://wwfeu.awsassets.panda.org/downloads/illegal_water_use_in_spain_may06.pdf

ecosystems (i.e. quality of water). This means that if a fish pass is built along a hydropower dam, as long as the riverine character is not restored, the fish population will not thrive. The natural flow is impacted both by river obstacles and water abstraction.

A 2015 study of two Welsh rivers investigated the impact of flow regime changes from water abstraction on two migratory species; twaite shad (*Alosa fallax*) and Atlantic salmon (*Salmo salar*). It found that movement of young salmon migrating to the sea was influenced primarily by flow and tide, with a clear preference for high velocity waters.[63] This is a risk all over Europe, but particularly in drier regions such as the Mediterranean, where drought and reduced water resources are more problematic.

Climate Change & Severe Weather

Drought affects 16 (22%) of the European migratory freshwater fish species assessed for the IUCN Red List (Figure 6) and 25% of those reported by the EU Member States in the Habitats Directive Article 17 (Figure 7).

It has been noted that freshwater biodiversity is highly vulnerable to climate change.[64] There are a number of threats to freshwater fishes and migratory fish that can be categorised under the over-arching threat of climate change. These include increasing temperatures, drought, increasing salinity, and extreme weather events. Stark changes to hydrological patterns, such as increased winter runoff and reduced summer runoff, are expected in the future in many European river catchments.[65] For diadromous fishes, increasing ocean temperatures force populations to move to higher latitudes and abandon their historic territories. A study of habitat losses in current range areas of 470 fish species found that 43% are predicted to experience losses in current range, with 8 species experiencing complete loss (including migratory species; *Barbus waleckii, Coregonus pallasii, Acipenser sturio, Lethenteron reissneri*).[66] Many of the previously mentioned threats, such as pollution, invasive species and water abstraction, are exacerbated by climate change.

Sporadic weather events of any sort will disrupt fish and we do not fully understand the impacts of climate change on migratory freshwater fishes. Migratory fishes may be especially susceptible to the effects of climate change, as it impacts both

[63] Smith, J. (2015). Impacts of water abstraction upon migratory fish species In the rivers Wye and Usk. University of Hull.
[64] Poff, N.L., Olden, J.D. & Strayer, D. (2012) Climate change and freshwater fauna extinction risk. *Saving a million species: extinction risk from climate change* (ed. by L. Hannah), pp. 309–336. Island Press, Washington.
[65] Schröter D, Cramer W, Leemans R, *et al.* (2005). Ecosystem service supply and vulnerability to global change in Europe. *Science* 310: 1333–37.
[66] Markovic, D., Carrizo, S., Freyhof, J., Cid, N., Lengyel, S., Scholz, M., Kasperdius, H., and Darwall, W. (2014) Europe's freshwater biodiversity under climate change: distribution shifts and conservation needs. *Diversity and Distributions;* 20, 1097–1107

ecosystems they inhabit during their life cycles, as well as migration routes.[67] A study of Australian grayling species concluded that the priorities for barrier removal to improve connectivity for migratory fishes should gradually shift towards dams at higher elevations, as climate change will make these habitats more suitable for them.[68]

One recent example comes from the River Oder in central Europe, during the summer of 2022. A significant fish die-off in the river garnered attention from across the continent as a serious environmental disaster. Investigations by a German expert group found that the cause was from salt discharges, leading to the mass proliferation of a brackish water algae (*Prymnesium parvum*), which produces a toxin that is fatal to fishes. Other experts in Poland believed that it was caused by high temperatures and very low water levels which contributed to poor water quality.

Hydrological modelling carried out in the framework of the Climate Resilient Flyway Network project lead by Wetlands International shows that 1 – 2 months of reduction in inundation length can be expected across the Mediterranean region and some parts of Central and Eastern Europe, while conditions might become more wet in other areas (Figure 10).[69]69 below In that project, comparing natural flow to business-as-usual water usage scenario has indicated that the impacts of climate change are exacerbated by the impacts of water extraction.

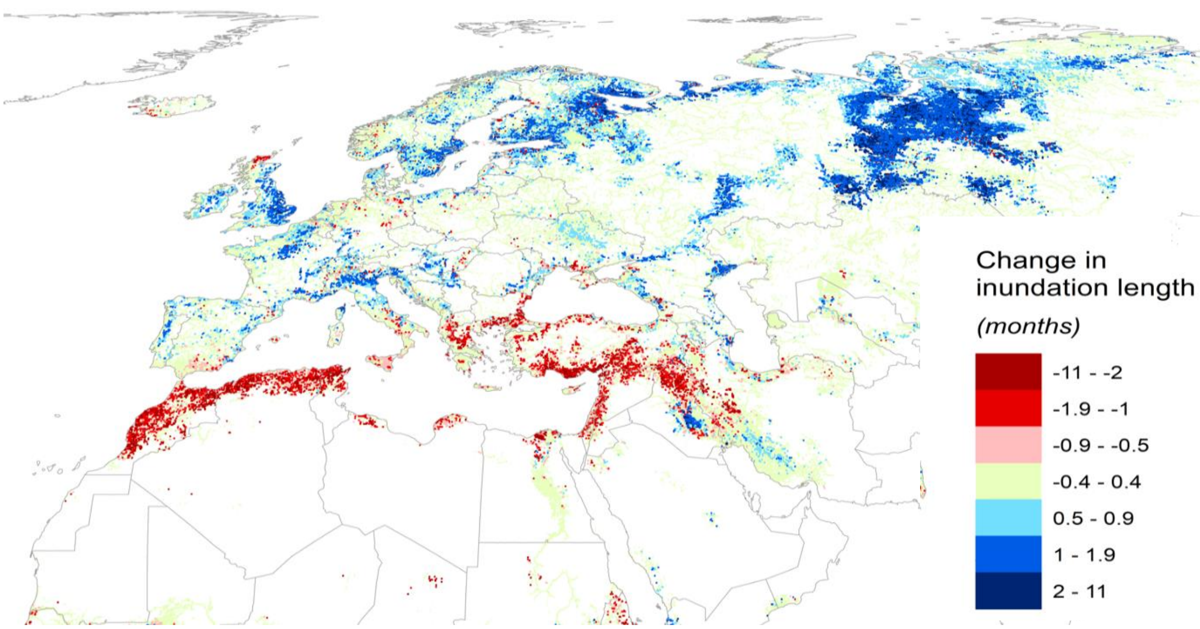

Figure 10. Modelled change in average inundation duration length in wetlands between baseline and the year 2050. The results shown are predicted inundation changes for two climate model results (HadGEM2-ES and IPSL-CM5A-LR) using the Representative Concentration Pathway RCP 6.0, averaged at the original 500m resolution. The

[67] Runge, C. A., Martin, T. G., Possingham, H. P., Willis, S. G., & Fuller, R. A. (2014). Conserving mobile species. *Frontiers in Ecology and the Environment*, 12, 395–402.
[68] Lin, H.Y., Bush, A., Linke, S., Possingham, H.P. & Brown, C.J. (2017). Climate change decouples marine and freshwater habitats of a threatened migratory fish. *Diversity and Distributions,* 23(7); 751-760.

inundation changes visualized in this map are the average predicted inundation duration change within a 5km radius of all wetland pixels (i.e., only pixels experiencing some inundation and excluding dryland pixels.)[69]

[69] **Anand, M. (2018). The future of flood-prone areas in Africa and Europe: predicting changing inundation patterns under climate change.**

Annex 3. Existing and proposed international legislation

Global And European Treaties

The Ramsar Convention on Wetlands and the Convention on Migratory Species (CMS) are the two most relevant global treaties for the conservation of migratory freshwater fishes. The Bern Convention is a European treaty focusing on the conservation of fauna and their habitats.

RAMSAR CONVENTION ON WETLANDS

The Ramsar Convention on Wetlands was adopted in 1971. One of the aims of the Ramsar Convention on Wetlands is to develop and protect a network of wetlands which are important for the conservation of global biological diversity and for sustaining human life.

Under the Ramsar Convention on Wetlands there are two criteria relevant for migratory fish species:

- Criterion 7: "[that a site] supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity";
- Criterion 8: "[that a site] is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend".

Criterion 7 focuses on the identification of sites that support a significant proportion of different aspects of fish diversity and is tailored more towards endemic than to migratory species. On the contrary, Criterion 8 focuses less on the fishes themselves but more on the ecological functions of the wetland and this includes several aspects relevant for migratory fishes, such as being a migratory path or nursery area.

So far, 142 Wetlands of International Importance (Ramsar Sites) were designated in Europe and in overseas territories of European countries under Criterion 7 and 260 under Criterion 8. 109 of these sites qualify under both criteria. However, these numbers include not only the sites for migratory freshwater fish species but for all fishes. Due to its voluntary nature, the Ramsar Site network offers less coverage than the Natura 2000 and the EMERALD networks in Europe.

CONVENTION ON MIGRATORY SPECIES (CMS)

This convention was adopted in 1979. It focuses on the conservation of all migratory species. Parties shall endeavour to conserve and restore the habitats of and remove or compensate the threats to endangered migratory species listed in Appendix I and prohibit their taking. Appendix II of the convention lists species that are in unfavourable conservation status and for which Parties can conclude agreements for their conservation.

Only one species of European migratory freshwater fish, European sturgeon (*Acipenser sturio)*, is listed in Appendix I, and eight sturgeon species and the European eel are listed in Appendix II. However, it is possible to consider taxa not specifically mentioned in the appendices of the CMS, as demonstrated by the CMS flyway instruments such as the Agreement on African-Eurasian Migratory Waterbirds (AEWA), Memorandum of Understanding on the Conservation of Migratory Birds of Prey in Africa and Eurasia and the African-Eurasian Migratory Landbirds Action Plan (AEMLAP).

BERN CONVENTION ON THE CONSERVATION OF EUROPEAN WILDLIFE AND NATURAL HABITATS

The Bern Convention was ratified in 1979 under the Council of Europe. The Bern Convention lists three of the 136 European migratory freshwater fish species in its Appendix II of strictly protected fauna species, and 57 species in its Appendix III of protected fauna species. Species listed on Appendix II should enjoy protection against their deliberate capture and killing, destruction of their breeding sites, disturbance, possession and trade. Any exploitation of species listed in Appendix III should be regulated to keep these species out of danger. In addition, Contracting Parties should coordinate their efforts for the migratory species listed in Appendices II and III.

19 of the 43 migratory freshwater fish that are Threatened or Near Threatened in Europe are not listed on the appendices of the Bern Convention, including six Critically Endangered species: *Acipenser gueldenstaedtii*, *Salmo ezenami*, *Acipenser nudiventris*, *Luciobarbus brachycephalus*, *Acipenser persicus*, and *Anguilla anguilla*.

EMERALD NETWORK

The Emerald Network is an ecological network comprised of Areas of Special Conservation Interest (ASCI) listed under the Bern Convention, and together with the EU Natura 2000 network forms the backbone of the Pan-European Ecological Network.

531 EMERALD Network sites are identified for 20 migratory freshwater fish species (Table 3) in 14 European countries outside of the EU (Table 4). Over 100 sites are designated in each of Ukraine, Russia, and the United Kingdom.

Table 3. Migratory freshwater fishes with EMERALD Network site designations

Species	Number of ASCI
Leuciscus aspius	239
Salmo salar	154
Eudontomyzon mariae	117
Pelecus cultratus	109
Lampetra planeri	74
Lampetra fluviatilis	50
Petromyzon marinus	43
Gymnocephalus baloni	28
Alosa tanaica	26
Alosa fallax	22
Hucho hucho	21
Alosa maeotica	19
Alosa alosa	17
Eudontomyzon danfordi	14
Acipenser sturio	7
Alosa immaculata	4
Acipenser naccarii	2
Alburnus mento	1
Barbus plebejus	1

Chondrostoma soetta	1

Table 4. Number of EMERALD Network sites per country designated for migratory freshwater fishes

Country	Number of ASCI
Ukraine	148
Russia	111
United Kingdom	111
Belarus	53
Norway	35
Moldova	16
Serbia	14
Armenia	9
Georgia	9
Azerbaijan	8
Switzerland	7
North Macedonia	5
Albania	4
Bosnia-Herzegovina	1

PAN-EUROPEAN ACTION PLAN FOR STURGEON[70]

It was adopted by the Standing Committee of the Bern Convention in November 2018 and also endorsed for implementation as an EU Species Action Plan under the EU

[70] https://rm.coe.int/pan-european-action-plan-for-sturgeons/16808e84f3

Habitats Directive in 2019. It covers eight European sturgeon species of which seven are Critically Endangered; Russian sturgeon complex (*Acipenser gueldenstaedtii, A. persicus-colchicus*), Adriatic sturgeon (*Acipenser naccarii*), Ship sturgeon (*Acipenser nudiventris*), Atlantic/Baltic sturgeon, (*Acipenser oxyrinchus*), Sterlet (*Acipenser ruthenus*), Stellate sturgeon (*Acipenser stellatus*), European sturgeon (*Acipenser sturio*), and Beluga (*Huso huso*). The geographical scope covers the European Union and neighbouring countries with shared basins such as the Black Sea, Mediterranean, North Eastern Atlantic Ocean, North Sea, Baltic Sea, and the main rivers draining into those basins.

The Pan-European Action Plan for Sturgeons is intended to serve as a guiding framework on the Pan-European level. It shall not replace national or regional plans in existence; on the contrary, it shall serve as a guiding framework for their development or renewal. National and/or regional plans on the level of river basins can provide more detailed analysis of threats, countermeasures to be taken as well as milestones, addressing progress on specific results. They can also address and incorporate the roles of responsible organisations in more detail.

The secretariat of the Bern Convention is mandated by Decision of the Standing Committee to coordinate the implementation of this Action Plan.

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between government. It aims to ensure that international trade in specimens of wild fauna and flora does not threaten the survival of these species. This is achieved thanks to a system of permits and certificates. The text was drafted following the adoption of a resolution at a meeting of members of the IUCN in 1963. The text of the Convention entered into force in 1975.

Endangered species of wild fauna and flora are listed in three different annexes. The most endangered species are listed in Annex I and are offered the greatest protection. Appendices II and III list the species that are not threatened with extinction for the time being or that are protected by certain Parties. CITES includes about 5,950 species of animals and 32,800 species of plants. The list identifies 81 *actinopteri* (ray-finned fishes), including sturgeons (*Acipenseridae*) and freshwater eels (*Anguilla anguilla*).[71]

OSPAR

[71] https://cites.org/eng/app/appendices.php

Also known as the Convention for the Protection of the Marine Environment of the North-East Atlantic[72], OSPAR is a legally binding convention and the current legislative instrument regulating international cooperation on environmental protection in the North-East Atlantic. It was open for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. It has been signed and ratified by Belgium, Denmark, the European Community, Finland, France, Germany, Iceland, Ireland, the Netherlands, Norway, Portugal, Spain, Sweden, the UK, Luxembourg and Switzerland. Despite being inland countries, Luxembourg and Switzerland signed and ratified the Convention due to connection with the River Rhine catchment which flows to the North Atlantic.

The Convention contains 5 annexes: the first 3 of which relate to pollution, Annex IV on the Assessment of the quality of the marine environment and Annex V on the protection and conservation of the ecosystems and biological diversity of the maritime area. Thus, it aims to protect the quality of the maritime environment through preventing and eliminating pollution, and protecting its biological diversity. This makes OSPAR relevant for the marine life stages of diadromous fish species.

CONVENTION FOR THE CONSERVATION OF SALMON IN THE NORTH ATLANTIC OCEAN

This Convention came about through a 1982 diplomatic conference in Reykjavik and was ratified in 1983 by six government parties; Canada, Denmark, Iceland, Norway, the United States of America, and the European Economic Community, then in 1984 joined by Sweden and Finland, and in 1986 the USSR (taken over by Russia in 1992). The Convention established the North Atlantic Salmon Conservation Organisation (NASCO), which consists of three councils; the North American Commission, the North-East Atlantic Commission, and the West Greenland Commission, as well as a Secretariat. It's overall purpose is to provide a forum for the study, analysis, and exchange of information on salmon stocks, to coordinate activities of the Commissions, and to make recommendations on scientific research, with the goal of conserving Atlantic salmon.[73] Of most relevance to Europe is the North-east Atlantic Commission of NASCO, which consists of Denmark (in respect of Faroe Islands and Greenland), the European Union, Norway, the Russian Federation, and the United Kingdom.

BENELUX TREATY

[72] https://www.ospar.org/
[73] NASCO. (2020). Handbook of Basic Texts. *North Atlantic Salmon Conservation Organisation.* https://nasco.int/about/

The 2009 Benelux decision is a framework for international cooperation among the 3 neighbouring countries which make up the Benelux Union; the Netherlands, Belgium, and Luxembourg. The Benelux framework has objectives to expand cross-border cooperation and to pursue and deepen Benelux cooperation as laboratory within the EU. As concerns migratory freshwater fishes, the Benelux decision (M2009) sets out that diadromous fish must be free to migrate in all river basins, with the following migratory species specifically mentioned; European eel, Atlantic salmon, Sea trout, and Flounder. The decision also developed a prioritization map, with the aim of removing all key obstacles by 2027.[74]

HELCOM

The Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area is a legally binding convention established in 1974 and signed in 1992 by Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia, Sweden and the European Union. The governing body of the Convention is the Helsinki Convention - Baltic Marine Environment Protection Commission, an intergovernmental organization also referred to as HELCOM[75]. In light of the adoption of the Marine Strategy Framework Directive (MSFD) 2008/56/EC, HELCOM established that it would act as the coordinating platform for regional implementation of the EU MSFD directive in the Baltic Sea Area.

The Convention's protection isn't limited to the sole seawater of the Baltic Sea, but also includes inland waters as well as the sea-bed. Thus, measures are also taken to reduce land-based pollution in the whole catchment area of the Baltic Sea, in alignment with the HELCOM Baltic Sea Action Plan adopted in 2007. The latter focuses on four areas of priority: eutrophication, hazardous substances, sea-based activities and biodiversity.

BUCHAREST CONVENTION

The Black Sea coastal and marine environments are protected by the Convention on the Protection of the Black Sea against Pollution, also known as the "Bucharest Convention", signed in April 1992 and ratified in 1994 by all six legislative assemblies of countries bordering the Black Sea: Russia, Turkey, Ukraine, Georgia, Bulgaria and Romania. The Black Sea Commission[76] is the intergovernmental implementing body of the Bucharest Convention, and deploys efforts towards the implementation of its

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[74] Government of the Netherlands. (2018). Measures for migratory fish, 2018. *Environmental Data Compendium.* https://www.clo.nl/en/indicators/en1350-measures-for-migratory-fish
[75] HELCOM, 2023, https://helcom.fi/
[76] Black Sea Commission, 2023 http://www.blacksea-commission.org/

second Strategic Action Plan for the Environmental protection and rehabilitation of the Black Sea.

Although legislative and institutional efforts have been made by all contracting parties of the Bucharest Convention to work towards the achievement of the 2009 Strategic Action Plan goals, further progress is currently on hold due to the war between Ukraine and Russia[77]. Furthermore, the conflict has direct effects on the freshwaters, coastal, and marine waters of the Black Sea and Azov Sea areas: destruction of infrastructure leading to leakages of wastewater, chemicals and pollutants, warships and munitions being sunk directly in the sea, noise disturbances, etc. The effects of the conflict are not monitored while the hostilities still occur, but we can expect effects on the environment and biodiversity.

BARCELONA CONVENTION

After UNEP established the Regional Seas Programme in 1974 to protect marine environments on the basis of a regional approach, the first UNEP initiative to be adopted under the Programme was the Mediterranean Action Plan (MAP). The latter was adopted by Mediterranean governments including Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syrian Arab Republic, Turkey as well as the European Union. To provide the commitments taken within the MAP with a solid regulatory and legal basis, the Convention for the Protection of the Mediterranean Sea against Pollution, also known as the Barcelona Convention[78], was adopted in February 1976. After the 1995 Rio Summit, MAP and the Barcelona Convention were revised to integrate and promote sustainable development, broadening the scope of their application to include the conservation of marine and coastal resources, thus including biodiversity.

In 2008, Contracting Parties committed to the Ecosystem Approach as an overarching work principle, leading to the adoption of 11 Mediterranean Ecological Objectives and a Roadmap to support national and regional efforts towards the achievement of Good Environmental Status (GES) in the Mediterranean, in synergy with other initiatives such as the 2008 EU Marine Strategy Directive.

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[77] **Editor. War and the Sea: How Hostilities Threaten the Coastal and Marine Ecosystems of the Black and Azov Seas – Ukraine War Environmental Consequences Work Group. 2022, https://uwecworkgroup.info/war-and-the-sea-how-hostilities-threaten-the-coastal-and-marine-ecosystems-of-the-black-and-azov-seas/./**

[78] https://www.unep.org/unepmap/who-we-are/barcelona-convention-and-protocols

Existing And Proposed European Union (EU) Legislation

EU regulations and directives represent one of the strongest legal frameworks in Europe. EU regulations have a direct legal effect in the EU Member States, while EU directives need to be transposed. However, both forms of legislation are enforced by the European Commission as the guardian of the EU treaties.

THE EU HABITATS DIRECTIVE

The Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (in short: the EU Habitats Directive) is one of the EU nature directives that protect habitats and species in the European Union. Fishes are amongst the taxonomic groups protected by this directive.

Annex II of the Habitats Directive lists the species for which sites of community interest (SCIs) should be designated and protected in accordance with the provisions of Articles 3–11. Together with the special protection areas (SPAs) designated under the Birds Directive, SCIs form the EU Natura 2000 network.

Annex II contains 69 species of fish and three groups that include all species belonging to one family or genus. Since the Habitats Directive came into effect, there have been taxonomical changes and new species discovered, which are reflected in Table 14 of the Explanatory Notes and Guidelines for Reporting under Article 17. This brings the total fish species listed under Annex II to 167 species.

There are 33 species of migratory freshwater fish occurring in the EU listed in Annex II, which accounts for 22% of all species listed. 16 of these species are potamodromous, 15 are anadromous, and one is estuarine. Of these, only the Critically Endangered Adriatic sturgeon (*Acipenser naccarii)* and European sturgeon (*Acipenser sturio),* (*acipenser oxyrinchus* was not known as a native species when the Directive came into force, it is now considered to be listed together with *A.sturio* in Annex II), as well as the now extinct Houting (*Coregonus oxyrinchus)* are listed as priority species for which the European Community has particular responsibility, both during the designation of SCIs and in relation to their management

Annex IV of the Habitats Directive contains the species for which Member States should establish strict protection prohibiting their deliberate capture or killing in the wild, their deliberate disturbance, and deliberate destruction or deterioration of their breeding and resting sites.

Annex IV lists nine fish species, one of which (*Rhynchocypris percnurus*) is not found in the European Union except in Italy, where it was introduced. Of the remaining eight species in need of strict protection, five exhibit some migratory behaviour. Adriatic

sturgeon (*Acipenser naccari)i,* European sturgeon (*Acipenser sturio)* and Houting (*Coregonus oxyrinchus)* are anadromous, while Iberian minnowcarp (*Anaecypris hispanica)* and Danube ruffe (*Gymnocephalus baloni)* are potamodromous. These five species account for 62% of the fishes listed in Annex IV, and all but one (*Gymnocephalus baloni*) are Threatened according to the European assessment of the IUCN Red List.

In the case of species listed in Annex V of the Habitats Directive, Member States shall ensure that any taking is compatible with maintaining their favourable conservation status.

Annex V contains 12 fish species and four groups that include all species within that family or genus. Accounting for these families of species, changes in taxonomy, and the removal of species not found within EU countries (including species that are endemic to the UK or Switzerland), results in a total of around 80 fish species. Of these fish, 31 could be considered migratory, accounting for 39% of all fish species protected by Annex V stipulations.

The Habitats Directive includes 54 migratory freshwater fish species found in the European Union on either one or two of Annexes II, IV, or V. A remaining 43 species that could be considered migratory and inhabit rivers and seas within the EU, are absent from the Habitats Directive. Fishes that exhibit some form of diadromous migratory behaviour (anadromous or catadromous) account for 22 species missing from the Annexes, as listed below. The IUCN Red List has assessed all but one of these species as Least Concern. The exception is the European eel (*Anguilla anguilla*) which is Critically Endangered, although it is noted that there is a separate EU regulation dedicated to this species. Of the potamodromous fishes not listed in the Annexes of the Habitats Directive, there are seven species that have a Threatened, Near Threatened or unknown status according to the latest IUCN Red List European assessments. *Chondrostoma vardarense* is Near Threatened. Prespa nase (*Chondrostoma prespense),* Common carp (*Cyprinus carpio),* Sonaghen (*Salmo nigripinnis)*, and Gillaroo (*Salmo stomachicus)* are Vulnerable. Perlfisch (*Rutilus meidingeri)* is Endangered, and Ferox trout (*Salmo ferox)* is Data Deficient.

NATURA 2000 COVERAGE OF MIGRATORY FRESHWATER FISH

2,595 Natura 2000 sites (14%) have been selected for 28 migratory freshwater fish species. Only one migratory freshwater fish species, the Black Sea Roach (*Rutilus frisiii),* has no Natura 2000 sites.

By far the most Natura 2000 sites have been identified for European brook lamprey (*Lampetra planeri)*, but more than 200 sites were also identified for five other species: Aral asp (*Aspius aspius)*, Atlantic salmon (*Salmo salar)*, European river lamprey (*Lampetra fluviatilis)*, Sea lamprey (*Petromyzon marinus)* and Twaite shad (*Alosa fallax)* (Table 5). Most of the Natura 2000 sites support only a small proportion

of the national population and are listed in Category C. This suggests that the Natura 2000 coverage of most migratory freshwater fishes is rather low.

Table 5. Numbers of Natura 2000 sites designated for migratory freshwater fishes by species and importance of the population. A: 100% - 15%, B: 15% – 2%, C: 2% - 0% of the total national population.[79]

Species	Not assessed	A	B	C	Total
Lampetra planeri	92	16	46	1030	1184
Aspius aspius	6	12	63	370	451
Salmo salar	2	32	94	309	437
Lampetra fluviatilis	4	12	87	316	419
Petromyzon marinus	4	15	52	244	315
Alosa fallax	12	18	57	182	269
Barbus plebejus	0	5	6	188	199
Alosa alosa	11	6	24	95	136
Parachondrostoma miegii	2	3	3	119	127
Gymnocephalus baloni	1	4	41	76	122
Pelecus cultratus	2	8	27	50	87
Hucho hucho	0	8	21	52	81
Eudontomyzon mariae	1	9	18	39	67
Chondrostoma soetta	0	0	2	62	64
Alosa immaculata	0	3	18	39	60
Acipenser naccarii	0	2	18	25	45
Anaecypris hispanica	2	1	17	23	43
Alosa tanaica	0	3	16	13	32
Eudontomyzon danfordi	0	0	7	24	31

[79] EEA (2022) Natura 2000 dataset end of 2021.

Acipenser sturio	5	9	2	2	18
Alburnus mandrensis	0	0	3	3	6
Alburnus mento	0	2	1	3	6
Parachondrostoma turiense	1	1	2	1	5
Alburnus schischkovi	0	1	1	2	4
Aulopyge huegelii	0	1	2	1	4
Alburnus sarmaticus	0	2	1	0	3
Alburnus vistonicus	1	0	2	0	3
Alosa maeotica	1	0	0	0	1
Total	147	173	631	3268	4219

There are Natura 2000 sites designated for migratory fishes in 24 of the 27 EU Member States (no sites are designated in Cyprus, Finland, or Malta). Most sites are in larger countries such as Germany, Italy, France, Spain and Poland, although Belgium has designated 141 sites for migratory freshwater fish (Table 6).

Table 6. Number of Natura 2000 sites per Member State[79]

Country	Number of Natura 2000 sites
Germany	713
Italy	296
France	294
Spain	249
Belgium	141
Poland	120
Romania	88
Slovakia	70

Latvia	68
Sweden	68
Denmark	67
Bulgaria	56
Estonia	47
Lithuania	46
Czech Republic	42
Hungary	40
Austria	39
Republic of Ireland	29
Croatia	25
Portugal	22
Slovenia	21
Netherlands	20
Greece	17
Luxembourg	17

EU EEL REGULATION - REGULATION (EC) NO 1100/2007

Since the 1980s, the population of the European eel (*Anguilla anguilla*) has declined, its recruitment having fallen by as much as ~95%, and it remains in a critical state.[80] To address this, the 2007 EU Eel Regulation provides a focus on the protection of European eel. It provides a framework for its recovery and sustainable use through long-term plans created by EU Member States, called Eel Management Plans. One of the key objectives of these national plans is to reduce mortalities of adult eel from anthropogenic sources to ensure at least 40% of their biomass is able to migrate to

[80] Council of the European Union. (2022). Future for European eel stock and those depending on it – Information from the Commission.

the sea, relative to "pristine" conditions without anthropogenic influences. This is referred to as the escapement target. The regulation stipulates that these plans should identify individual river basin habitats as so-called eel management units (EMUs) - and report on resident eel populations. They should also include measures for improving stocks (such as reducing fishing activities, improving habitats and making rivers passable), a time schedule, and description of enforcement measures. This was accompanied, in 2010, by a ban on trading eel with countries outside the EU Member States.

In 2020, the European Commission published an evaluation of the regulation, calling it an important milestone that had generated notable progress in reducing fishing of the species. The Sustainable Eel Group (SEG) also notes that the regulation has increased awareness and resulted in widespread protective actions for conservation.[81] Both the EC and SEG note potential areas of improvement for the regulation's implementation; the need for an EU-wide traceability system, improvement of non-fishing measures, and the need for better integration between relevant policies (WFD, Natura 2000, CITES, CMS etc.). The evaluation recognised that any future recovery of the species would be on a decadal scale.

A 2022 report from the Council for the Exploration of the Sea (ICES) provided the third technical evaluation of the Eel Management Plan progress reports.[82] Using eel stock indicators of biomass and mortality reported by MS, they conclude that the regulation's escapement target had not been achieved, with only 23% of reported EMUs having met this target. This is also considering that less than 50% of EMUs submitted reports on biomass and mortality indicators. It must be noted that they were unable to provide a scientific evaluation of progress to achieving the objectives of the regulation, due to insufficient information. However, their general conclusion was that escapement eel biomass had not increased across the EMUs, and there was instead evidence of further declines.

The above findings and recommendations from ICES indicate that there are no signs of recovery, and Member States have seen no overall progress towards the escapement target. The European Commission also acknowledged the need for considering more environmental and socio-economic aspects such as river continuity and nature restoration, rather than the focus on fisheries and aquaculture to achieve targets. Additionally, they call for a holistic approach in collaboration between different stakeholders and countries.

While the ICES report was not able to evaluate the effectiveness of conservation measures being taken by MS for eels, it did note that there were 1019 total measures reported in 2021, with the highest number of measures relating to commercial fisheries, recreational fisheries, and hydropower and obstacles. This can provide an

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[81] https://www.sustainableeelgroup.org/the-european-eel-regulation-effective-elements-to-be-sharpened-further-ambition-and-action-needed/

[82] ICES. (2022). EU request for technical evaluation of the Eel Management Plan progress reports. ICES Advice: Special Requests. Report. https://doi.org/10.17895/ices.advice.19902958.v2

indication of management activity, but not on the level of success these measures have had on eel conservation.

Evaluation of the effectiveness of the Eel Regulation is difficult due to differences in how the Eel Management Plans are prepared and reported on by MS (for example the way indicators are estimated, establishing the values for pristine conditions), as well as a lack of reported plans. This meant that there were large data gaps and inconsistencies in the information available during evaluation, making it almost impossible to compare between MS. The report provides recommendations for alternative methods for estimating indicators to reduce this issue and improve consistency in the future. However, the difficulty for evaluating effectiveness of the regulation is a fundamental issue.

Another recommendation is the need for Eel Management Plans to consider transboundary and international collaboration. Art. 6 of the Eel Regulation states that for EMUs that cover more than one MS, Eel Management Plans shall be prepared jointly with concerned member states. However, a stipulation is that if this coordination would result in delays to the submission of the plans, MS may submit them for their national part of the river basin. To date, the European Commission has received and adopted only one joint transboundary plan for the Minho River in Spain and Portugal. Increased regional coordination, such as in the Baltic Sea and Mediterranean region, should be considered by MS to strengthen conservation for eel. Transboundary plans could benefit the coordination of planning, implementation, monitoring, and evaluation for eel management.

The Working Group on the management of European Eel (WGMEASURES-EEL), held online in February 2022, is a step towards increased regional coordination for strengthening eel conservation. It gathered scientific experts and representatives from the General Fisheries Commission for the Mediterranean (GFCM), the Food and Agriculture Organization of the UN (FAO), and administrations from the Mediterranean sea to underline the importance of increasing available knowledge on eels, strongly advocating for the cooperative interaction of bodies with different mandates. The Working Group's workplan includes the creation of a permanent GFCM expert group on European eel in the Mediterranean to consolidate the network of experts (scientific and administration), ensuring Mediterranean-wide coordination and providing mutual assistance in addressing stock-wide issues. It will also coordinate with other organizations e.g. CITES, CMS and UNEP/MAP.[83]

In 2021, the annual Advice from ICES was for zero catch of the species through all life stages and in all habitats.[84] ICES reiterated its advice for zero catch in 2022. At the

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[83]FAO, GFCM. (2022). Scientific advisory Committee on Fisheries. *Working group on the management of European eel.* Report. https://gfcm.sharepoint.com/EG/Report%20v2/Forms/AllItems.aspx?id=%2FEG%2FReport%20v2%2F2022%2FWGMEASURES%2DEEL%2FWGMEASURES%5FEEL%5F2022%5Freport%2Epdf&parent=%2FEG%2FReport%20v2%2F2022%2FWGMEASURES%2DEEL&p=true&ga=1

[84] ICES. (2021). European eel (*Anguilla anguilla*) throughout its natural range. https://ices-library.figshare.com/articles/report/European_eel_Anguilla_anguilla_throughout_its_natural_range/1863970

Fisheries Council Meeting (Council of the EU) held in December 2022, fishing opportunities for 2023 were agreed for the Atlantic, Kattegat and Skagerrak, as well as the Mediterranean and the Black Sea, following two proposals by the Commission. They agreed to prohibit recreational fisheries and to extend the current closure at sea for any commercial eel fishing activity from 3 to 6 months to protect eel stocks.[85] The EU is not in favour of a zero catch policy, and focuses on other threats to eel, such as dams, turbines and pollution.

EU WATER FRAMEWORK DIRECTIVE -2000/60/EC

The aim of the 2000 EU Water Framework Directive (WFD) is to achieve Good Ecological Status (GES) of all inland and coastal water bodies. Ecological status examines the biological quality elements in surface water, including phythobenthos, aquatic plants, macroinvertebrates, and fishes. This status is expressed as the deviation of current ecological condition from the undisturbed reference condition.

Many water bodies in Europe have a similar but different target to GES, rather Good Ecological Potential (GEP), if they are designated as an Artificial or Heavily Modified Water Body. This goal allows for exceptions to GES when the water body has human objectives for flood protection, navigation, etc.

Fishes are assessed through surveillance monitoring for the WFD, undertaken through fish stock surveys in rivers, usually using electro-fishing. Annex V[86] of the WFD outlines that the composition, abundance, and age structure of fish fauna should be examined in all surface water body types – rivers, lakes, and transitional waters.[87] Table 1.2.1 of this Annex provides definitions for ecological status in rivers in relation to the different assessment elements. A sub-section of this table for rivers can be found below (Table 7). Similar definitions are provided for lake and transitional water habitats.

Table 7: Adaptation of Table 1.2.1 Annex V WFD: Definitions of high, good and moderate ecological status in rivers.

Element	High Status	Good Status	Moderate Status
Fish fauna	Species composition and abundance correspond totally	There are slight changes in species composition and abundance from the type-specific	The composition and abundance of fish species differ moderately from the

[85] Council of the European Union. (2022). Council approves fishing opportunities for 2023 in EU and non-EU waters. Press release. https://www.consilium.europa.eu/en/press/press-releases/2022/12/13/council-approves-fishing-opportunities-for-2023-in-eu-and-non-eu-waters/
[86] https://lexparency.org/eu/32000L0060/ANX_V/
[87] European Commission. (2000). Water Framework Directive 2000/60/EC. Annex V.

	or nearly totally to undisturbed conditions. All the type-specific disturbance-sensitive species are present. The age structures of the fish communities show little sign of anthropogenic disturbance and are not indicative of a failure in the reproduction or development of any particular species.	communities attributable to anthropogenic impacts on physico-chemical and hydromorphological quality elements. The age structures of the fish communities show signs of disturbance attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements, and, in a few instances, are indicative of a failure in the reproduction or development of a particular species, to the extent that some age classes may be missing.	type-specific communities attributable to anthropogenic impacts on physico-chemical or hydromorphological quality elements. The age structure of the fish communities shows major signs of anthropogenic disturbance, to the extent that a moderate proportion of the type specific species are absent or of very low abundance.

Annex IV on Protected Areas covers the types of areas eligible for the register of protected areas required under Article 6. This includes areas designated for the protection of economically significant aquatic species and for the protection of species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites.[88] In the original 2000 legislation as well as the most recent 2014 revision, there is no mention of rare or threatened species being considered as part of the assessment or aims of the Water Framework Directive. However, Annex V does state that Member States should monitor relevant parameters indicative of the biological quality element most sensitive to the pressures to which the water bodies are subject.

To help guide Member States in administering the WFD, a Common Implementation Strategy (CIS) was derived shortly after the Directive came into force. This includes a variety of guidance documents[89], including No. 7 – Monitoring under the WFD, No. 13 – Overall Approach to the Classification of Ecological Status and Ecological Potential, and No. 27 – Deriving Environmental Quality Standards.

[88] European Commission. (2000). Water Framework Directive 2000/60/EC. Annex IV.
[89] https://ec.europa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm

Within No. 7 – Monitoring under the WFD,[90] figure 3.1 provides a tree diagram of quality elements for rivers, including the presence of sensitive taxa as one of the four indicators for fish. Table 3.1 of the same guidance document outlines the key features of each biological quality element (QE) for rivers and includes sensitive species diversity as a measured parameter indicative of QE for fish. This is repeated in figure 3.2 and table 3.2 for guidance of lakes. Guidance document no. 32 – Biota Monitoring[91] clearly states that *there is no specific recommendation about which species should be sampled*.[91]

The overarching legislation and guidance of the WFD does not therefore provide information or recommendations on the monitoring or protection of rare or threatened species, nor does it outline which fish species would characterise good ecological quality in specific types of water bodies.

Regarding migratory fish species, long distance migrants are mentioned as an option to serve as a criterion for the assessment of disruption in river continuum within 2.12.3 Heavily Modified and Artificial Water Bodies of guidance document No. 7.

RIVER BASIN MANAGEMENT PLANS

The WFD requires the preparation of River Basin Management Plans (RBMP) by Member States across 6 year cycles. Since it is a directive, it requires EU countries to achieve a certain result but leaves them free to choose how to do so. Thus, it does not specifically require for each country to remove a certain amount of dams or to build fish passages for example. The river basin planning aims to algin and streamline plans and mechanism in Europe to improve water quality, manage flood risks and enhance biodiversity.

Overall, RBMP implementation in Member States has proven to be insufficient. The Living Rivers Europe (LRE) analysis of 2022-2027 draft river basin management plans shows that the majority of water bodies will not reach good status by 2027 (Figure 11).[92] There is a "*general failure of Member States to integrate water protection and the WFD's environmental objectives for Europe's waters into other policies, in particular energy, agriculture and infrastructure policies*".[92] Among the 13 draft 2022-2027 RBMPs assessed, only 2 reach a good score (Kemijoki and the transboundary

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[90] European Union. (2003). Common Implementation Strategy for the Water Framework Directive (2000/60.EC) Guidance Document No 7 on Monitoring under the WFD. https://circabc.europa.eu/sd/a/63f7715f-0f45-4955-b7cb-58ca305e42a8/Guidance No 7 - Monitoring (WG 2.7).pdf

[91] European Union. (2014). Common Implementation Strategy for the Water Framework Directive (2000/60.EC) Guidance Document No 32 on Biota Monitoring. https://circabc.europa.eu/sd/a/62343f10-5759-4e7c-ae2b-12677aa57605/Guidance No 32 - Biota Monitoring.pdf

[92] Schmidt, G., Rogger, M. (2021). The final sprint for Europe's rivers. An NGO analysis of 2022-2027 draft river basin management plans. *LRE*. https://wwfeu.awsassets.panda.org/downloads/wwf_the_final_sprint_for_rivers_full_report_june_2021_1.pdf

Rakkolanjoki river in the Vuoksi RBD, all in Finland), 5 a moderate score (Loire-Bretagne in France, Austrian Danube, Slovak Danube, Slovak Vistula and Scheldt and Meuse in Belgium), and 6 a poor score (Dutch Rhine, German parts of the international Rhine and the Elbe RBDs, Eastern Alp, Southern Apennines, and International Odra RBD). The NGOs' recommendations are: dedicate a substantial budget to the Programme of Measures, ensure a cost recovery approach, phase out harmful national and European subsidies, limit exemptions to exceptional cases, align the RBMPs with national biodiversity ambitions, and actively promote the uptake of NBS.

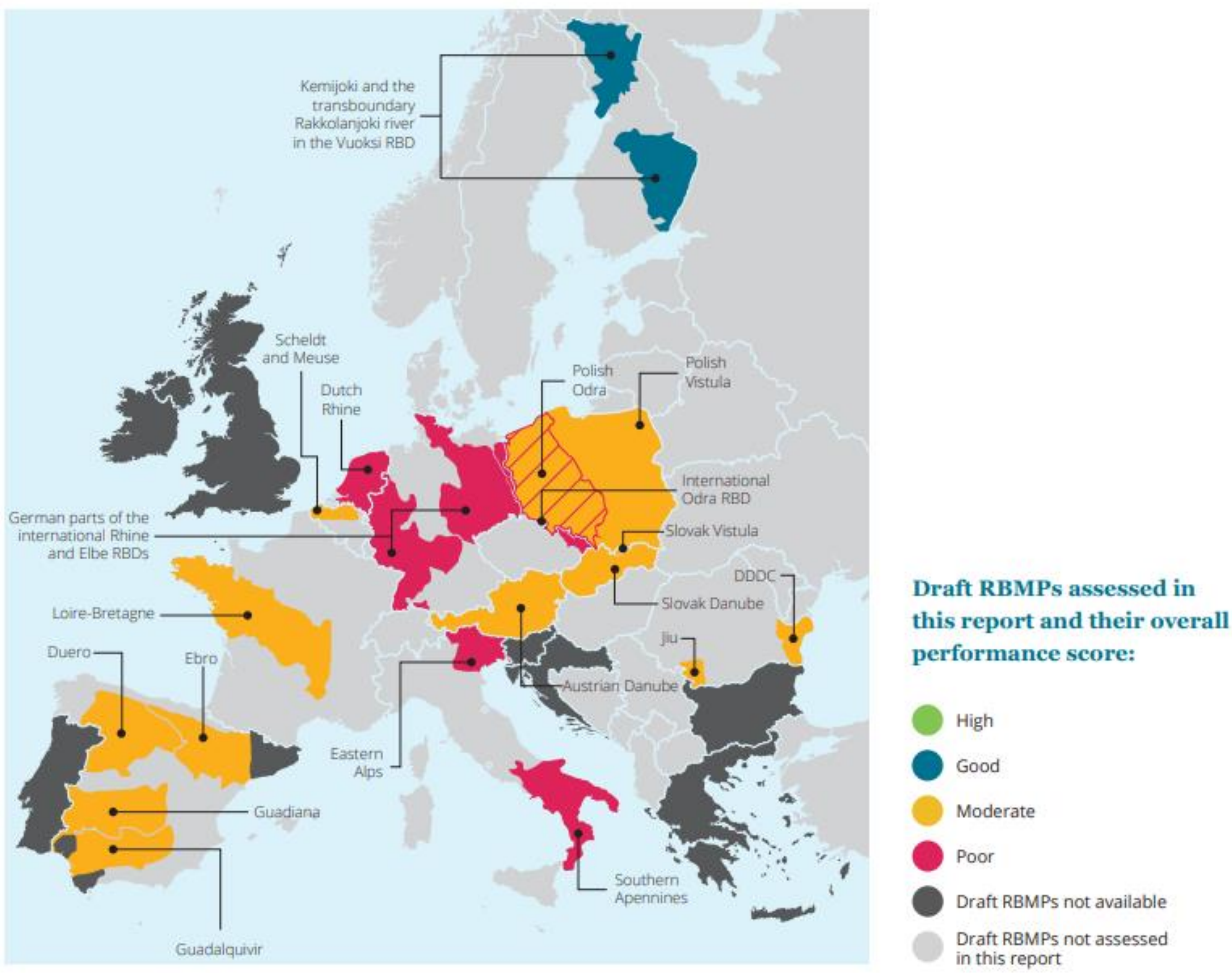

Figure 11. Draft RBMPs 2022-2027 in September 2021 assessed in "The Final Sprint for Europe's Rivers: an NGO analysis of 2022-2027 Draft RBMPs" report and their overall performance score[93].

EU BIODIVERSITY STRATEGY

[93] **ibid.**

The EU Biodiversity Strategy for 2030 was adopted in 2020 as part of the European Green Deal. Several of its targets are highly relevant for the conservation and recovery of migratory freshwater fishes:

- **Establish protected areas covering 30% of the land and sea areas of Europe including 10% of strictly protected areas;**
- **Restore 30% of species and habitats currently not in favourable conservation status to that category or to show positive trend;**
- **Put forward legally binding nature restoration targets to restore the degraded habitats.**

The protected area target is to be achieved through voluntary pledges by the EU Member States, due by the end of 2022 and followed by an EU wide assessment in 2023. The difference between the target and the current extent of terrestrial protected areas is limited (6%). However, there is a potential to extend protection to cover some of the key spawning and nursery habitats of migratory freshwater fishes.

The sub target of 10% strict protection offers some opportunities for substantial change of the management regime, primarily within existing protected areas.

The species recovery target focuses on the species that are already listed in the annexes of the Habitats Directive. The Member States' reports under Article 17 of the Habitats Directive show that the majority of migratory freshwater fish species are in unfavourable conservation status and their status is rather deteriorating than improving. Member States will have to make their pledges for species recovery by the end of 2022 and the sufficiency will be assessed in 2023. Migratory freshwater fish species represent a challenging case, especially in river basins that extend beyond national boundaries, as their recovery would require coordinated measures of habitat restoration and harvest management along the entire migratory corridor.

On June 23, 2022, the European Commission submitted its proposal for a new EU regulation on nature restoration. From a migratory freshwater fish conservation point of view, the main elements of the proposal include the requirement of restoring habitats for species listed on the annexes of the Habitats Directive (Art. 4(3)) and the restoration of 25,000 kilometres of river and their floodplains by 2030. The proposal also requests the EU Member States to submit their national nature restoration plans within two years after the regulation comes into force (i.e. the plans are expected in 2026 or 2027 depending on when the proposal will be adopted).

Annex 4. On-going Swimway Conservation Efforts in Europe

There are several key management measures that have been employed for the conservation of freshwater fish across Europe over the past century. A 2021 paper published *in Frontiers in Ecology and the Environment* describes the "Big Five" important considerations for diadromous species management:[94]

- Installation of fish passages
- Removal of barriers to migration
- Restocking
- Habitat restoration
- Fisheries management

Using one strategy alone may not be effective in improving conservation of migratory fishes. For example, restocking in rivers can temporarily increase fish populations, but if barriers exist the animals will still not be able to complete their life cycles. This paper suggests that an integrated management approach comprising more than one of these considerations should be used for the most effective conservation. In addition, it notes that the best strategy may be to focus efforts on improving all elements of habitats in select rivers to effectively improve fish populations there, rather than spreading limited resources across more areas. According to the authors, this could mean accepting a sacrifice of some waterways for human purposes while retaining others for optimal ecological integrity.

The application of ecological flows is a relatively new and promising management solution. In contrast to 'environmental flows', 'ecological flows' prioritise ecological considerations over economic ones, taking into account the flow and water levels required to sustain ecological function of the species residing there. Future research is needed using empirical field data, as most studies on ecological flows have been based on predictive modelling[95].

Technical solutions to swimway conservation in Europe

Options for improving habitat connectivity include the removal or partial breaching of barriers such as dams, installation of fish passages, or in the case of sluices, leaving gates open during critical migration periods. Removal of barriers is however the best

[94] Verhelst, P., Reubens, J., Buysse, D., Goethals, P., Van Wichelen, J. & Moens, T. (2021). Toward a roadmap for diadromous fish conservation: the Big Five considerations. *Frontiers in Ecology and the Environment*. 19. 10.1002/fee.2361.
[95] Ibid.

choice, and there are numerous examples of the rapid recovery of riverine ecosystems and their resident fish communities immediately following dam removals.

REMOVAL OF BARRIERS

Despite the research being done on improving the effectiveness of fish passes as a technical solution to river connectivity, the preferred option remains the removal or at least partial breaching of barriers, especially those considered obsolete. This is also the case because fish passes do not address the problem of hydrological changes in the river caused by barriers.

Launched in 2016, Dam Removal Europe is a growing network of citizens and organisations coming together to share resources and support each other to remove barriers on rivers in Europe. Building off the success of the dam removal movement in the United States, it uses similar findings on the cost-effectiveness of removing barriers compared with ongoing repair and maintenance costs to advocate for their removal across the continent. While the organization uses the term 'dam', they note that this word refers to any structure that impounds a river and so changes its natural hydromorphology and hydrology.

The strategies that Dam Removal Europe employs to catalyse this include;

- Mapping all dams across Europe (AMBER)
- Creating a priority list for dam removals
- Integrating dam removals into River Basin Management Plans (WFD)
- Involving local communities
- Ensuring that alternatives to new dams are seriously considered.[96]

In October 2022, Dam Removal Europe estimated that 6,767 barriers have already been removed from rivers across many European countries including Austria, Belgium, Cyprus, Norway, Slovakia and Montenegro. In 2021 alone, 239 were removed.[97]

The Adaptive Management of Barriers in European Rivers (AMBER) project got underway in 2020 to better quantify the total number of barriers on the continent and map their locations. This is designed to drive awareness and offer a tool to support and prioritise their removal. The project aims to provide the first realistic estimate of river fragmentation in Europe. With the majority of barriers being smaller than 10 meters, and many obsolete and forgotten about, their location, density and typology has thus far been largely unknown in most European countries.[96] AMBER partners with various stakeholders from 11 countries to use citizen science and new technology (eDNA, drones), as well as valuation of ecosystem services, in order to map barriers and assess their effects on freshwater species and habitats.[98] It not only increases awareness of the problems of river fragmentation, but encourages the public to get

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96 Gough, P., Fernández Garrido, P., Van Herk, J., (2018). Dam Removal. A viable solution for the future of our European rivers. Dam Removal Europe.
97 https://damremoval.eu/
98 WFMF. (2022). AMBER. https://worldfishmigrationfoundation.com/portfolio-item/amber/

involved in data collection. One of the key outputs from the project is the live interactive atlas of barriers in Europe.[99]

Another technique for improving fish passage when barrier removal is not possible is the temporary opening of barriers during peak migration time periods. An example of this has taken place at the Haringvliet barrier on the coast of the Netherlands, which has allowed partial opening of limited seawater intrusion through the sluices.[100] As a result, the Rhine and Meuse rivers were reconnected to the North Sea for the first time in 47 years. This allows the delta to once again experience the tide and the transition from freshwater to seawater. The project aims to help nature restoration, by letting fish migrate again in the Delta and by establishing a stable brackish habitat. The Afsluitdijk dam fish migration river project is another example of alternative solution when removal of barrier cannot occur. Started in November 2020, the construction of this four kilometers fish migration river through the dam should enable diadromous fish species to navigate between the salty waters of the Wadden Sea to the freshwaters of IJsselmeer[101]. However, fish have to face other anthropogenic disturbance, such as artificial light at night, the noise produced by the sluices, and other structures, and fisheries in the estuary.[102]

INSTALLATION OF FISH MIGRATION MEASURES

Fish passes, or fishways, have been used since at least the 18th century as a means to provide a passage for migratory fish to swim around a barrier without removing it. There are many different types of fish passes, from more natural to technical designs, but all must include an obvious entrance near the barrier that is easily accessible to fishes (Table 8). Numerous guides and manuals exist to help practitioners design and implement the most effective fish pass for their situation, such as England's Environment Agency Fish Pass Manual.

Where space is lacking for the implementation of a fish pass, other measures could include fish lifts and trap-and-transport[103].Fish lifts are vertical reservoirs that move fish from downstream of a barrier to upstream, often used on tall barriers. Trap-and-transport is the human intervention of moving fish, which is much more labour intensive and dependent on species' resilience to stress.

There is not strong evidence on the effectiveness of fish passes in providing the level of connectivity needed for species to move through their habitats. Additionally,

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[99] https://amber.international/european-barrier-atlas/

[100] Griffioen, A.B., Winter, H.V., and van Hal, R. (2017). Prognose visstand in en rond het Haringvliet na invoering van het Kierbesluit in 2018. Wageningen, the Netherlands: Wageningen University & Research.

[101] https://theafsluitdijk.com/projects/fishmigrationriver/why/

[102] Hoek, S., Jin, R., et al. (2021). The return of fish migration to the Dutch River Delta. https://www.delta21.nl/wp-content/uploads/2022/02/ACT-Vismigratierivier.pdf

[103] Verhelst, P., Reubens, J., Buysse, D., Goethals, P., Van Wichelen, J. & Moens, T. (2021). Toward a roadmap for diadromous fish conservation: the Big Five considerations. *Frontiers in Ecology and the Environment*. 19. 10.1002/fee.2361.

salmonids and other strong swimmers have been the focus of most research on the subject, at least until 2016.[104] A 2012 quantitative study of fish passes reviewed articles written between 1960 and 2011, finding that upstream passage had a passage efficiency of 42% and downstream passage of 69%.[105] As these rates reflect each barrier, the cumulative effects of fish needing to pass multiple barriers means that very few would successfully navigate a river with several barriers. For example, if a river stretch had 5 dams, only 15% of the stock would make it past all 5 dams downstream. These efficiency rates differed considerably with the type of fish pass as well as species, with salmonids often 2-3 times more likely to pass through than non-salmonids. Larger fish, such as sturgeon, pose a further challenge as the dimensions needed for them to be able to pass through are much larger, increasing costs for construction. Despite many global studies of fish pass efficiency, there still exists the problem of a lack of standardization in their evaluation.[106]

In order for fish passes to be effective, they need to be suitable for the largest possible number of fish species of various sizes and life stages and ensure that upstream and downstream movement is possible over a range of flow types.[107] This means the design of multi-species fish passes (e.g., vertical slots and natural) or the inclusion of multiple types of fish passes. There should be a greater consideration of downstream fish migration. Furthermore, monitoring and maintenance of fish passes should be mandatory to ensure they operate effectively over their entire lifecycle.

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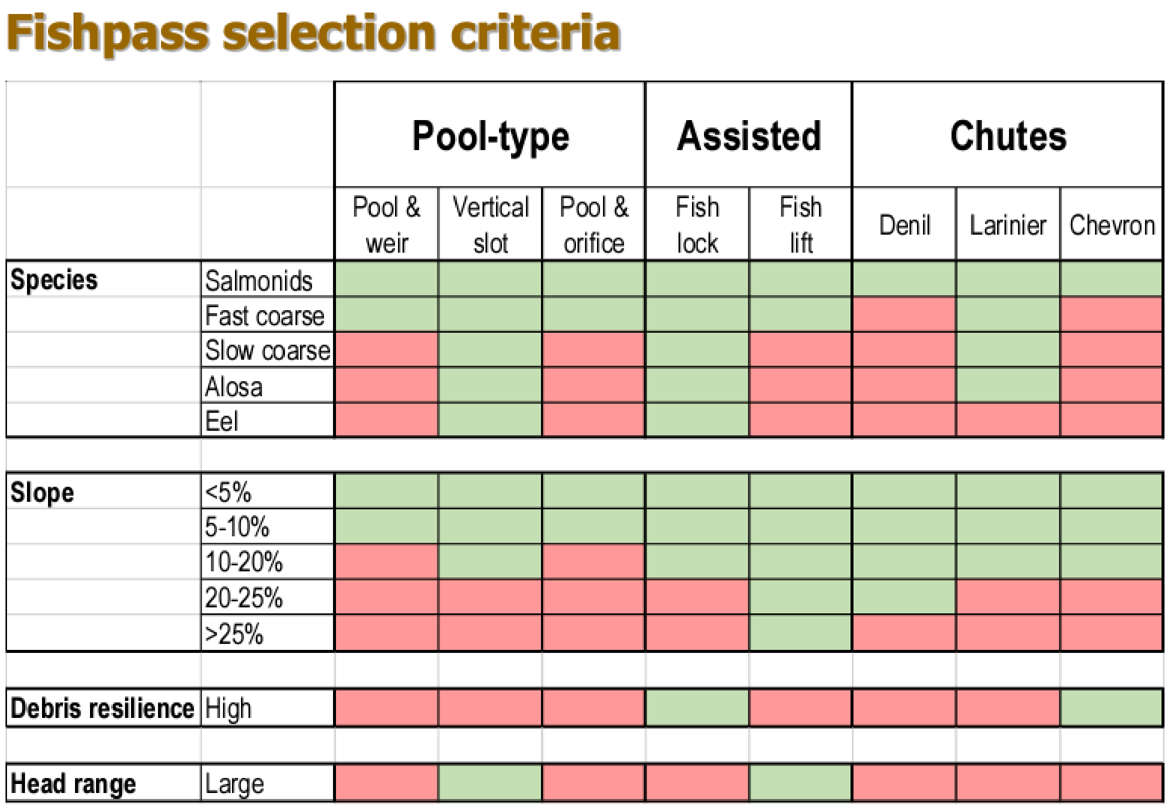
[104] Kemp, P.S. (2016). Meta-analyses, metrics and motivation: Mixed messages in the fish passage debate. *River Research and Applications* 32(10), 2116-2124.
[105] Noonan, M., Grant, J. & Jackson, C. (2012). A Quantitative Assessment of Fish Passage Efficiency. *Fish and Fisheries*. 13. 10.1111/j.1467-2979.2011.00445.x.
[106] Hershey, H. (2021). Updating the consensus on fishway efficiency: A meta- analysis. *Fish and Fisheries.* 22:735–748. https://doi.org/10.1111/faf.12547
[107] AMBER Consortium (2020). Impacts of Barriers on Biodiversity of Running Waters. AMBER Policy Brief No 3., 14 pp. https://amber.international/policy-briefs/

Table 8 : Fishpass selection criteria[108]



A problem arising from hydropower plants for migrating fish is mortality from hydroelectric turbines while swimming downstream. This can be difficult to combat since fish tend to follow the bulk water flow which enters the turbine intakes. To prevent this, various methods have been used, such as fish-friendly turbines, guiding screens, louvres, wire screens skimming walls, and partial depth fine screens.[109]

RESTOCKING

Like trap-and-transport solutions, fish restocking has been a popular management measure for increasing fish populations over the past 150 years in Europe. It is also called breeding and release programme, and is common for several species, such as sturgeon and eel.

[108] Garcia de Leaniz, C. & de la Fuente, J. (2018) Fish passes, a brief introduction. Webinar presentation available at : https://europe.wetlands.org/wp-content/uploads/sites/3/dlm_uploads/2018/02/Fish-passes-Garcia-de-Leaniz-De-La-Fuente_Webinar_Feb2018_secured.pdf
[109] FIThydrowiki. (2020). Downstream fish migration. *FIThydro.* https://www.fithydro.wiki/index.php/Downstream_fish_migration

The solution has proven itself in the case of sturgeon. It saved the species from extinction in Europe, thanks to releases in the Danube. But in other cases, the method has not shown any positive impacts. ICES has advised to stop restocking eel in European rivers as there is no net benefits to the reproductive potential of the population. Out of a precautionary approach, they advise to stop stocking eel.

While still regularly employed, this activity addresses symptoms rather than the underlying causes of species declines, making its effectiveness questionable. Adding to its questionable effectiveness is that there is often little monitoring of restocked fish to determine whether the measures has been successful or not. The method is labour intensive and expensive. Furthermore, its effectiveness is also limited due to genetic effects – native species have evolved greater environmental adaptations putting restocked fish at a disadvantage. Stocked fish may experience high levels of stress when introduced into new habitats, which could lead to unsuccessful adaptation. There is also the 'hatchery selection' of restocked fish which are often grown in hatcheries where inbreeding and mutations are more common. Therefore, it is recommended that restocking is used as a last resort where it is unlikely that natural recolonization would occur and only with species closely related to the natural populations.

HABITAT RESTORATION

Further to the above-mentioned technical solutions for protecting swimways, another key method is habitat restoration. With many riverine environments heavily modified by humans in Europe, with multiple sources of pollution and development along their banks, the restoration of riverine ecosystems to their more natural states will support the conservation of migratory freshwater fishes that use them throughout their lives. Apart from improving connectivity across migration barriers (both longitudinally and latitudinally), creating more natural in-channel and riparian habitats providing breeding or nursery habitats is needed to increase the carrying capacity of rivers for migratory fish.

Swimway projects

There are certain river basins that have considerably greater coordination among countries and stakeholders compared to others. Some key examples are provided below.

UK

Project 'Unlocking the Severn'

Partners: Canal & River Trust, Severn Rivers Trust, Environment Agency, Natural England.

Funders: Heritage Fund and EU LIFE programme.

This project is focused on restoring the migratory pathways of Twaite shad (*Alosa fallax*) on the River Severn. Weirs and other barriers have cut Twaite shad off from their traditional spawning grounds in the upper reaches of the River Severn. The project aims to restore connectivity along the river for these and other migratory fishes. Four fish passes were constructed on individual weirs to permit this connectivity, and early data suggests it has been successful in allowing the passage of Twaite shad as well as Sea lamprey.

River Obstacles App[110]

An interactive map application enables people to send in photos and details of obstacles that they see in UK's rivers. This participatory map identifies the location of the obstacle, its type, its height and length, whether there is a fish or an eel pass present and photos of the obstacle. You can access the results map on the River Obstacles website,[111] where you can filter by obstacle type (weir, dam, culvert, ford, sluice, lock, flapgate and other) and by origin (man-made, natural or unknown).

The app was used by 97 volunteers from the Thames Catchment Community Eel Project to survey 100km of river for barriers to eel migration to help target action to restore eel populations in the Thames catchment.

Thames Fish Migration Roadmap

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[110] https://river-obstacles-theriverstrust.hub.arcgis.com/

[111] https://river-obstacles-theriverstrust.hub.arcgis.com/pages/results-map

An interactive web map application[112],[113] visualises barriers on rivers in the Thames basin, displaying locations where fish passes are located, quality of habitats, fish species presence, and distribution data (Figure 12). It allows layering and filtering of data related to swimways, both for migratory fishes and separately just for the European eel. It also shows upstream connectivity for fishes, i.e., where is considered open for them, and where is closed from barriers.

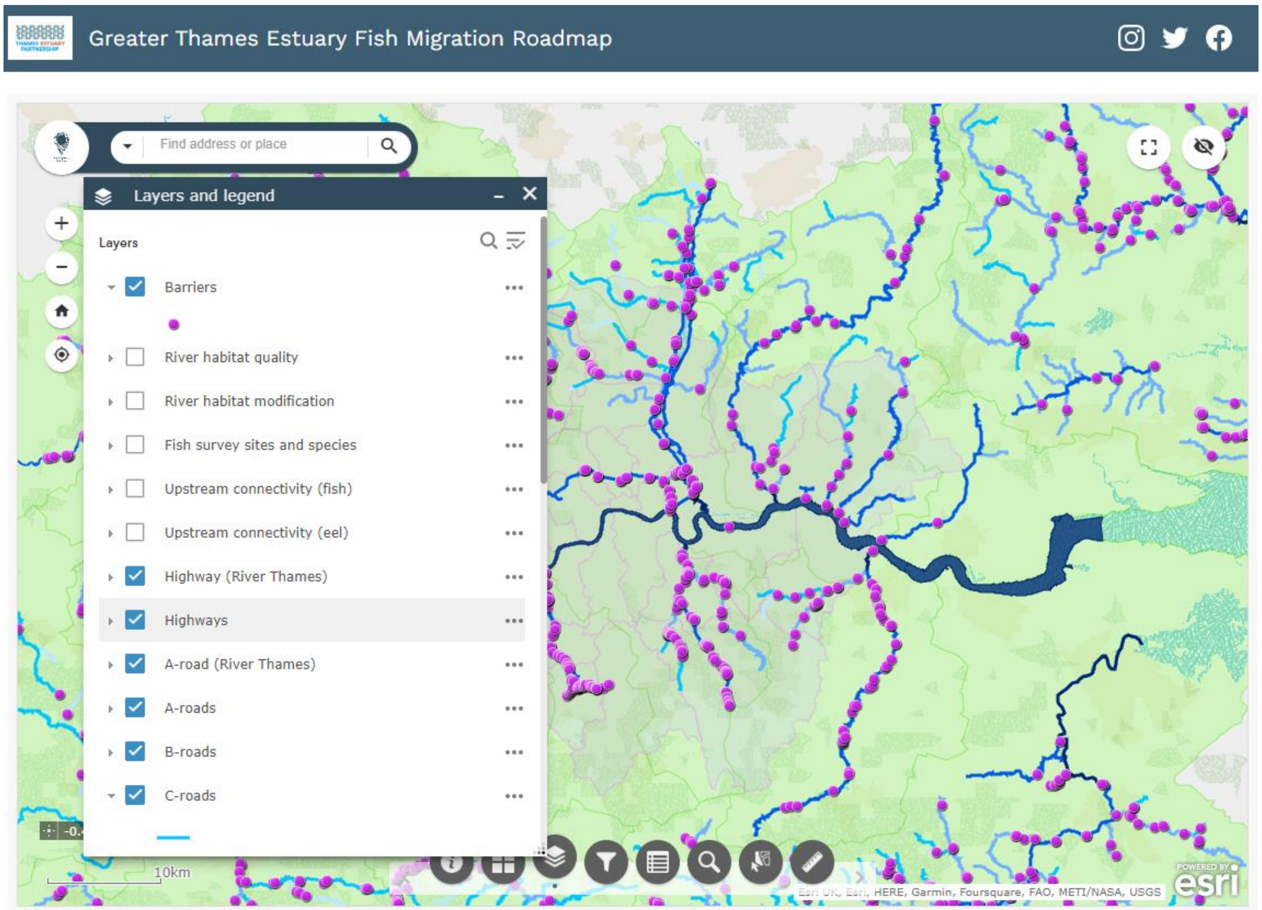

Figure 12. Screenshot of the Greater Thames Fish Migration Roadmap[114]

RiverLife project – Forth Rivers Trust Scotland

This is a completed project that has worked with local communities and partner organisations (the Forth Rivers Trust, West Lothian Council and City of Edinburgh Council) between 2016 and 2021 to carry out a range of engagement and restoration work to improve historic issues and engage communities with their local rivers. The 5-year project made improvements to the River Almond and River Avon catchments

[112] https://fishroadmap.london/
[113] https://storymaps.arcgis.com/stories/20ca53d7ee854edd9bc59636f81651b1
[114] https://fishroadmap.london/

through initiatives such as the creation of fish passes, and ladder and barrier easements. Another important project should be launched by the Forth Rivers Trust in early 2023, called the Bathgate Water Restoration Project. This £1.2 million 4-year programme aims to create a 'large, high-quality, accessible and wildlife-rich nature park on former industrial land'.[115]

NORTHWEST EUROPE

Swimway Wadden Sea

An example of international cooperation along swimways is that of the Swimway Wadden Sea, which links Denmark, Germany and the Netherlands. As one of the world's largest intertidal wetlands, it was separately named a UNESCO World Heritage Site in 2009 (Germany, the Netherlands) and 2014 (Denmark). Since 1978 these countries have collaborated in protecting the ecology of this region, signing the Joint Declaration on the Protection of the Wadden Sea in 1982. 1987 saw the creation of the Common Wadden Sea Secretariat (CWSS) which oversees the Trilateral Wadden Sea Cooperation (TWSC) between the three states. After several decades of working together, an action programme called the Trilateral Wadden Sea Swimway[116] Vision was released in 2019, which follows on from the 2010 trilateral fish targets.[117] This action programme runs from 2018-2024 with initiatives falling within the frameworks of four pillars: research and monitoring; policy; measures; stakeholder involvement; communication and education.

Salmon Comeback

Upstream of the Wadden Sea, a coalition of organisations formed for the conservation of Atlantic salmon (*Salmo salar*) in the upper Rhine river basin, called the Salmon Comeback[118] campaign. Launched in 2013 by WWF Switzerland and coordinated by the European Rivers Network (ERN), it includes 26 NGOs, government organisations, and private sponsors. It also works closely with international authorities such as the International Commission for the Protection of the Rhine (ICPR) which drafted a Master Plan Migratory Fish Rhine (2009, updated 2018).

LIFE Project Maifisch

[115] https://forthriverstrust.org/project/bathgate/
[116] https://rijkewaddenzee.nl/project/visstrategie-en-ontwikkelen-swimway-benadering/
[117] SWIMWAY (2019). Trilateral Wadden Sea Swimway Vision Action Programme. Common Wadden Sea Secretariat, Wilhelmshaven, Germany.
[118] https://www.salmoncomeback.org/

Faced with the progressive decrease of the distribution range of the Allis shad (*Alosa Alosa*) in the eastern Atlantic and North Sea over the last 150 years, where dense populations of Allis shad used to live, migrating from saltwater to freshwater to breed, the LIFE Project Maifisch[119] tried to provide a solution to the slow disappearance of the species in the Rhine River. Between 2007 and 2010, the project sought to conserve and protect the Allis shad through re-introduction to the Rhine system of larvae, with the aim to achieve a self-sustaining population that would return to the same river to breed in the future without pursuing ongoing restocking activities.

The project consisted of the development of a breeding programme in France (where the *Alosa Alosa* was still present naturally), the establishment of a transportation methodology and the development of an appropriate release process enabling fishes to survive the transition into the wild, all these steps covering three breeding seasons (2008-2010). In 2011, 30 juvenile Allis shad, whose marking revealed they had been released by the programme, were caught in the lower Rhine near the German/Dutch border. They were the first juveniles to be caught there for more than 50 years. Hence, the project allowed the fish to develop healthily and appropriately, and to successfully migrate downstream. Various guidance documents setting out the learning from the outcomes of the project have been issued, and the project has been followed up by another LIFE project carrying on the reintroduction and monitoring of Allis shad population in the Rhine

Nationale Visroutekaart

The National Fish Route Map, or *Nationale Visroutekaart*[120] in Dutch (NVRK), is a practical tool developed by the Dutch Ministry of Infrastructure and Water Management, aimed at facilitating the integration of fish migration routes into water management plans. The map allows users to switch between different scales, from a map of the Netherlands to maps of water boards management areas or department of Rijkswaterstaat. It includes details enabling zooming in on individual fish passages and provides information per bottleneck and passage. Finally, problematic barriers appear on the map, as well as the ones which have already been removed, and one can see the effect both have on the connectivity of the water system.

SOUTHERN EUROPE

Zingel Asper in the Rhône River

Conservation efforts to safeguard the critically endangered Zingel asper population of the Rhône[121] river started with a first LIFE project initiated in 1998. A second LIFE project took place between 2004 and 2010, and was rapidly followed by a National

[119] LIFE Maifisch Project - LIFE 3.0 - LIFE Project Public Page (europa.eu)
[120] https://storymaps.arcgis.com/collections/a32b5fce9c6840dfa9ee309e739c5c04
[121] https://aprondurhone.fr/

Action Plan from 2012 to 2016. Over these decades, the once seldom knowledge on this endemic freshwater fish species expanded tremendously. This allowed for reintroduction of individuals in some of the less polluted areas of the Rhône Basin, such as the Ardèche, the Durance, the Drôme, and the Beaume. Fish passes adapted to the Zingel asper particularities were built, mitigating some of the impacts habitat degradation and river discontinuity have on the species. A second National Action Plan is currently underway and will further the previous efforts until 2030.

LIFE Project Po River

The Po River is the longest river in Italy, its basin being the home of almost a third of Italy's population as well as the one of 11 European priority fish species and more than 40 native fish species, 15 of which are endemic or sub-endemic to the area. Due to important agricultural activities in the Po river basin, as well as numerous dikes preventing flood-risk and a scattered management system of the area, the common fish conservation targets clash with the diverse range of local interests. This situation led to the development of the LIFE Project Con.Flu.Po[122] between 2012 and 2017. This project aimed at restoring connectivity in the Po river basin in order to open a migratory route for *Acipenser naccarii* and 10 fish species in Annex II of the Habitat Directive. This project encapsulated the construction of the biggest fish passage in Italy near the Isola Serafini Dam in Lombardy: this 450 km water corridor now allows sturgeons, twaite shad and other native Po River fishes to migrate freely again.

LIFE Project KANTAURIBAI

The Bay of Biscay, flowing through basins shared by 3 regions and 2 countries: Navarre and Gipuzkoa (Spain) and the Atlantic Pyrenees (Nouvelle-Aquitaine, France), is not exempt from ecological fragmentation. The high density of impassable obstacles interrupting rivers' continuity in the area, along with various historical and geographical factors and genetic isolation hinder the conservation of habitats and species in the bay. The LIFE project KANTAURIBAI[123] launched in 2022 and running until 2027, aims at improving the conservation status of key species and habitats of rivers flowing into the Bay of Biscay. This will be done by restoring the ecological connectivity of rivers in the area, installing monitoring schemes, and tackling other pressures such as invasive species. In doing so, the project will safeguard migratory freshwater fish species such as salmon, lamprey, shad and eel.

[122] https://webgate.ec.europa.eu/life/publicWebsite/index.cfm?fuseaction=search.dspPage&n_proj_id=4315
[123] **LIFE 3.0 - LIFE Project Public Page. https://webgate.ec.europa.eu/life/publicWebsite/project/details/101074197.**

The Migra Miño-Minho project

On the Iberian peninsula, an international project between partners in Spain and Portugal was a finalist for the EU Natura 2000 Award in 2022. The Migra Miño-Minho project[124], initiated in 2017, aims to improve the ecology of the Miño river across borders in order to improve the state of conservation of migratory freshwater fishes (Figure 13). There are several migratory fishes found in the river basin, but the target species for the project are Atlantic trout (*Salmo trutta)*, Atlantic salmon (*Salmo salar),* Twaite shad (*Alosa fallax),* Sea lamprey (*Petromyzon marinus*) and the European eel (*Anguilla anguilla).* Partners of the project include the Government of Galicia, Miño-Sil Hydrographic Confederation (Spain), Institute for the Conservation of Nature and Forests (Portugal), University of Santiago de Compostela (Spain), Portuguese Environment Agency, CIIMAR – Interdisciplinary Center for Marine and Environmental Research (Portugal), and Municipal Chamber of Vila Nova de Cerveira (Portugal). Thus the project integrates public sector as well as research institutions. As of 2022, 11 barriers have been removed in the Miño river basin, and thousands of juvenile salmon and eel have been released.[125] In addition, they have used innovative fish ladder technology, raised awareness of migratory fish populations, and coordinated strategy for fishing regulations.

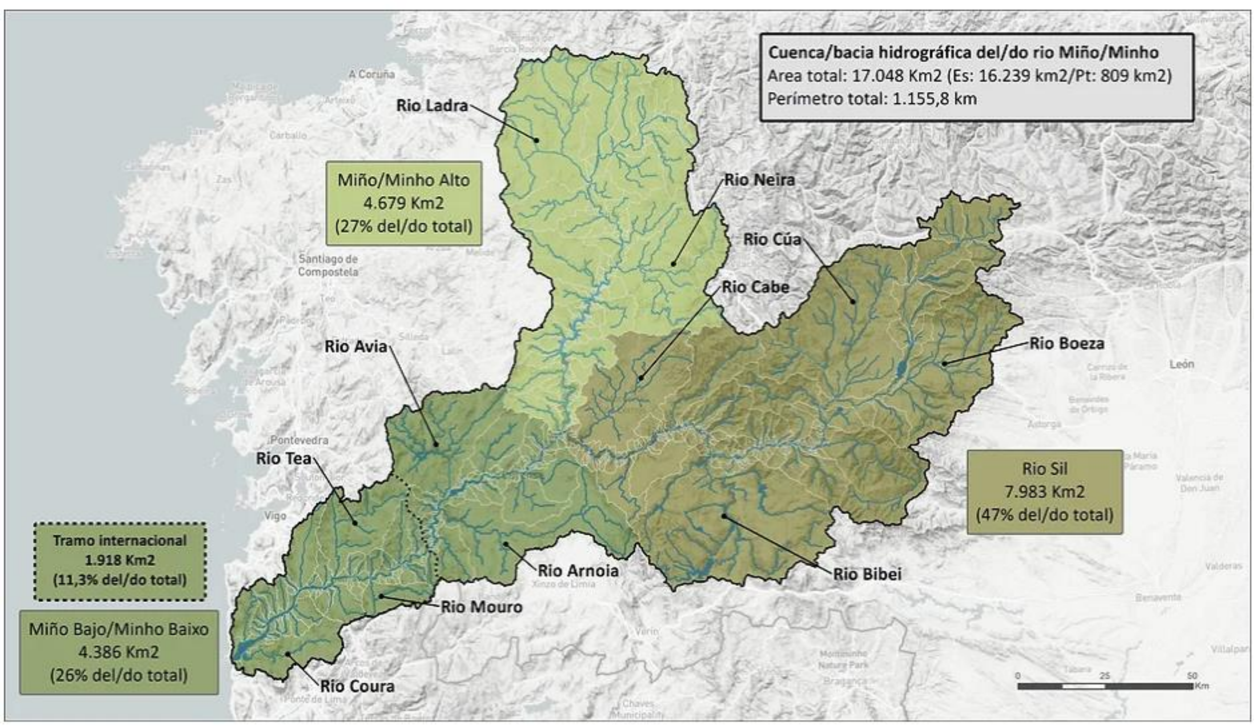

Figure 13. Mino Water Basin[126]

[124] http://migraminho.org/
[125] http://migraminho.org/la-xunta-realiza-una-suelta-de-6-000-esguines-en-tui-para-reivindicar-la-candidatura-del-proyecto-migra-mino-al-premio-natura-2000-de-la-comision-europea/
[126] https://pt.pecriominho.org/hidrografia

Vjosa River and the "Save the Blue Heart of Europe Campaign"

The Vjosa/Aoos River is one of the last wild free-flowing rivers in Europe outside of Russia. Flowing from Greek mountains (where it is called Aoos), through Albania to the Adriatic Sea, together with its tributaries it forms an ecosystem of great biodiversity of national and global importance. Some 31 fish species have been reported to be present in the river system, among which the European eel and several sub-endemic species such as the Pindus stone loach The campaign "Save the Blue Heart of Europe"[127], coordinated by international NGOs such as Riverwatch, EuroNatur and the IUCN, with the help of partner organizations and local governments in the Balkan countries, aims at protecting these rivers from the threat posed by more than 3.400 small hydropower projects.

After more than 10 years of efforts, on March 15th 2023, the Albanian River Vjosa has been proclaimed Europe's first Wild River National Park[128], granting the river system a very high level of protection. This is the first of many successes to come, and the campaign continues to bring together various partners and stakeholders to further conservation projects on the Vjosa and in the Balkans.

DANUBE BASIN

There are several ongoing efforts going on in the Danube basin, especially for the protection of sturgeon species.

Sturgeon in the Danube River

An Action Plan for Danube Sturgeon was adopted by the Standing Committee of the Bern Convention (2005), with the goal of securing viable populations of all Danube sturgeon species. The International Commission for the Protection of the Danube River (ICPDR) has declared sturgeons as flagship species to foster restoration of ecological corridors and developed an ICPDR sturgeon strategy.[129] In 2010, the European Commission adopted the EU Strategy for the Danube Region (EUSDR), through which the Danube Sturgeon Task Force (DSTF) was developed. The Task Force is a network of national and international public entities, NGOs and academic institutions, working towards the conservation of sturgeons in the Danube River Basin and Black Sea. The DSTF promoted the Sturgeon 2020 program. The latest update of

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[127] « IUCN Helps Protect Vjosa in Albania, the Last Wild Free-Flowing River in Europe ». IUCN, https://www.iucn.org/story/202209/iucn-helps-protect-vjosa-albania-last-wild-free-flowing-river-europe.

[128] March 2023. The Guardian, https://www.theguardian.com/environment/2023/mar/22/hydropower-goldrush-europe-first-wild-river-national-park-vjosa-albania-aoe.

[129] https://www.icpdr.org/main/activities-projects/sturgeons-danube-basin

the Danube River Basin Management (2021) includes several measures for improving connectivity and sturgeon conservation in particular.

ICPDR is also involved in the We Pass projects (currently phase 2) that is working on designing fish passage solutions for sturgeon through the iron gate dams. Phase 1 was concluded with a general positive feasibility. Phase 2 is expected to deliver technical design options until 2024.[130]

HELCOM Action Plan for the Protection and Recovery of the Baltic Sturgeon

This Action Plan was drafted and compiled by the members of the HELCOM Project Group on Baltic sturgeon restoration (now HELCOM Expert Group on Sturgeon Remediation – EG STUR). It was in response to HELCOM Habitat (now HELCOM State & Conservation) who requested in 2014 a harmonized outline for the restoration works to bring back the locally extinct Baltic sturgeon. The Action Plan was adopted by the 40th Meeting of the Helsinki Commission (HELCOM 40-2019).

It is structured around four segments with specific goals:

- **Biodiversity, with its goal of a "Baltic Sea ecosystem is healthy and resilient". Actions advised are setting up a representative network of marine and coastal protected areas and preventing the introduction of non-native species.**
- **Eutrophication, with its goal of a "Baltic Sea unaffected by eutrophication". Actions advised are reducing the amounts of nutrients entering rivers from diffuse sources or reducing nutrient pollution from "hotspots".**
- **Hazardous substances and litter, with its goal of a "Baltic Sea unaffected by hazardous substances and litter". Action advised are preventing the environmentally harmful use of hazardous substances or further reducing the amounts of hazardous substances entering the sea in rivers and from the air.**
- **Sea-based activities, with its goal of "Environmentally sustainable sea-based activities". Actions advised are reducing emissions and waste discharges and improving preparedness to respond to any accidents and pollution incidents.[131]**

MEASURES

MEASURES is a major INTERREG project implemented in 2018-2021. It united the 10 countries along the Danube (Germany, Austria, Slovakia, Slovenia, Hungary, Croatia, Serbia, Romania, Bulgaria and Ukraine) to restore aquatic ecological corridors for migratory fish species. During the project, focus was testing new methodologies,

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[130] https://www.icpdr.org/flowpaper/viewer/default/files/nodes/documents/icpdr_annual_report_2021.pdf

[131] Baltic Marine Environment Protection Commission. (2019). The Baltic Sea Action Plan. A new environmental strategy for the Baltic Sea Region. https://helcom.fi/wp-content/uploads/2019/10/Baltic-Sea-Action-Plan-Brochure.pdf

developing strategies for restoring ecological corridors, supporting implementation in future management plans, and restocking of two sturgeon species in Hungary (*Acipenser ruthenus*) and Romania (*Acipenser gueldenstaedtii*). One of its final outputs was a 100-page strategy document which describes the problem, the results of the research, strategies for governance arrangements, priority measures (river continuity, conservation hatcheries, habitats and corridors, policy coordination) as well as supporting activities.

A Horizon lighthouse project will start on 1 January 2023, called "Danube4all".[132] It has more than 40 international partners aiming to ultimately establish a Danube Basin Restoration Action Plan. This includes the conceptualisation of transboundary biodiversity monitoring across the Danube countries to assess more accurately migratory fish status during a transboundary survey (e.g. Joint Danube Survey) or by the development of an online screening tool to assist with the selection and prioritising of restoration measures along with the Restoration Action Plan for the whole river basin.

NORDIC COUNTRIES

NOUSU Migratory Fish Programme

Launched in March 2012, Finland's migratory fish programme NOUSU, managed by the Ministry of Agriculture and Forestry, is an ambitious programme supporting projects to restore fish migration routes.

Migratory fish projects have inspired different stakeholders to cooperate in different parts of Finland, and led notably to the restoration of a rapid in the River Tainionvirta, that discharges into Päijänne, the second largest lake in Finland[133]. The small-scale hydropower dam obstructing the river has been demolished in 2022, enabling the run of Lake Ladoga salmon to their spawning areas. Other fishways are under construction in different parts of Finland, contributing to the success of the programme.

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[132] https://www.danubeparks.org/news/danubeparks-general-assembly-2022

[133] « Demolition of Virtaankoski Hydropower Plant Opens River Tainionvirta to Migratory Fish in Lake Päijänne ». *Maa- Ja Metsätalousministeriö*, https://mmm.fi/en/-/demolition-of-virtaankoski-hydropower-plant-opens-river-tainionvirta-to-migratory-fish-in-lake-paijanne

Pärnu River Basin

The Pärnu River in Estonia is one of the country's largest river basins and the most important salmon river in the country, where other migratory freshwater fish species such as the spined loach or the river lamprey can be found. The Estonian Environment Agency, financially supported by the EU Cohesion Fund, bought the Sindi Dam, located 14km from the estuary, and demolished it in 2019 after extensive consultations with the local community. Two other dams have also been removed in the following years in the Pärnu River, and four others on its tributaries.

Altogether, the project helped reopen a historical salmon migration route, and improve the riverine habitat in the Pärnu River basin, with a total of 3 300 km of interconnected river system restored. This project has been selected to be a finalist for the 2022 Natura 2000 awards[134], as it is an example of river restoration in Europe: the removal of fish barriers has brought ecological benefits throughout the river basin, improving the conservation status of 32 species living in the river.

[134] *Improving the Pärnu River Basin for Its Migratory Fish*. https://environment.ec.europa.eu/topics/nature-and-biodiversity/natura-2000-award/current-edition/improving-parnu-river-basin-its-migratory-fish_en.

Annex 5. Migratory Freshwater Fish Species In Europe

Table 9: Migration, Red List and conservation status of European freshwater fish.

Common Name	Scientific name	Migratory strategy	EUROPE IUCN Red List Category	EU28 IUCN Red List Category	Habitats Directive	Bern Convention
Azov-Black Sea sturgeon	*Acipenser gueldenstaedtii*	Anadromous	CR	CR	V	
Adriatic sturgeon	*Acipenser naccarii*	Anadromous	CR	CR	II; IV	II
Barbel (Ship) sturgeon	*Acipenser nudiventris*	Anadromous	CR	CR	V	
Atlantic sturgeon	*Acipenser oxyrinchus*	Anadromous	NE	NE	V	
Persian sturgeon	*Acipenser persicus*	Anadromous	CR	-	-	
Sterlet sturgeon	*Acipenser ruthenus*	Potamodromous	VU	VU	V	III
Sevruga	*Acipenser stellatus*	Anadromous	CR	CR	V	III
Baltic (European) sturgeon	*Acipenser sturio*	Anadromous	CR	CR	II; IV	II
Giant sturgeon	*Huso huso*	Anadromous	CR	CR	V	II, III
Common eel	*Anguilla anguilla*	Catadromous	CR	CR	-	
Big-scale sand smelt	*Atherina boyeri*	Estuarine	LC	LC	-	
North African shad	*Alosa algeriensis*	Anadromous	DD	DD	II; IV	III
Alice shad	*Alosa alosa*	Anadromous	LC	LC	II; IV	III

Caspian shad	*Alosa caspia*	Anadromous	LC	-	II; IV	
Twaite shad	*Alosa fallax*	Anadromous	LC	LC	II; IV	III
Pontic shad	*Alosa immaculata*	Anadromous	VU	EN	II; IV	III
Caspian anadromous shad	*Alosa kessleri*	Anadromous	LC	-	II; IV	
Black Sea shad	*Alosa maeotica*	Estuarine	LC	LC	II; IV	
Azov shad	*Alosa tanaica*	Anadromous	LC	LC	II; IV	
Volga Shad	*Alosa volgensis*	Anadromous	EN	-	II; IV	
Caspian Sprat	*Clupeonella caspia*	Anadromous	LC	-	-	
Azov Sea sprat	*Clupeonella cultriventris*	Anadromous	LC	LC	-	
Don spined loach	*Cobitis tanaitica*	Potamodromous	LC	-	II	
Carp bream	*Abramis brama*	Semi-anadromous, Potamodromous	LC	LC	-	
Caspian shemaya	*Alburnus chalcoides*	Semi-anadromous, Potamodromous	LC	-	II	
	Alburnus istanbulensis	Potamodromous	LC	-	-	
	Alburnus leobergi	Semi-anadromous	LC	-	-	
Madras shemaya	*Alburnus mandrensis*	Potamodromous	CR	CR	II	III
Seelaube	*Alburnus mento*	Potamodromous	LC	LC	II	III
Caspian shemaya	*Alburnus mentoides*	Potamodromous	EN	-	-	III

Iznik Shemaya	*Alburnus nicaeensis*	(Potamodromous)	EX	NA	-	
Pontian Shemaya	*Alburnus sarmaticus*	Semi-anadromous	EN	CR	II	III
	Alburnus sava	(Potamodromous)	NE	NE	-	
Resowska shemaja	*Alburnus schischkovi*	Potamodromous	EN	EN	II	III
Scoranza	*Alburnus scoranza*	Potamodromous	LC	-	-	
Van Shah Kuli	*Alburnus tarichi*	(Potamodromous)	(NT)	NA	-	
Vistonida shemaya	*Alburnus vistonicus*	Potamodromous	CR	CR	II	III
Iberian minnowcarp/ Jarabugo (Spain)/ Saramugo (Portugal)	*Anaecypris hispanica*	Potamodromous	EN	EN	II; IV	III
Aral asp, Mesopotamian Asp	*Aspius aspius*	Anadromous, Potamodromous	LC	LC	II; IV	III
	Aulopyge huegelii	Potamodromous	EN	EN	II	
Blue bream	*Ballerus ballerus*	Potamodromous	LC	LC	-	III
Zobel	*Ballerus sapa*	Semi-anadromous	LC	LC	-	III
Large spot barbel	*Barbus balcanicus*	Potamodromous	LC	LC	V	
Barbel	*Barbus barbus*	Potamodromous	LC	LC	V	
Terek barbel	*Barbus ciscaucasicus*	Potamodromous	LC	-	V	
	Barbus kubanicus	Potamodromous	LC	-	V	

Italian barbel	*Barbus plebejus*	(Potamodromous)	LC	LC	II; IV	III
Prespa barbel	*Barbus prespensis*	Potamodromous	LC	LC	V	
	Barbus waleckii	Potamodromous	LC	LC	V	
White bream	*Blicca bjoerkna*	(Potamodromous)	LC	LC	-	
Kuban nase	*Chondrostoma kubanicum*	Potamodromous	LC	-	-	
Nase/ Sneep	*Chondrostoma nasus*	Potamodromous	LC	LC	-	III
Prespa nase	*Chondrostoma prespense*	Potamodromous	VU	VU	-	
Italian nase	*Chondrostoma soetta*	Potamodromous	EN	EN	II	III
	Chondrostoma vardarense	Potamodromous	NT	NT	-	
	Chondrostoma variabile	Potamodromous	LC	-	-	
Common carp	*Cyprinus carpio*	Potamodromous	VU	VU	-	
Beaked dace	*Leuciscus burdigalensis*	Potamodromous	LC	LC	-	
Ide/ Golden orfe	*Leuciscus idus*	Potamodromous	LC	LC	-	
Common dace	*Leuciscus leuciscus*	Potamodromous	LC	LC	-	
Aral barbel/ Shorthead barbel	*Luciobarbus brachycephalus*	Semi-anadromous	CR	-	V	
Bulatmai barbel	*Luciobarbus capito*	Semi-anadromous	VU	-	V	
	Luciobarbus graellsii	Potamodromous	LC	LC	V	
	Luciobarbus guiraonis	Potamodromous	VU	VU	V	

Júcar nase	*Parachondrostoma arrigonis*	Potamodromous	CR	CR	II	III
Ebro nase	*Parachondrostoma miegii*	Potamodromous	LC	LC	II	III
Madrija/ Turia nase	*Parachondrostoma turiense*	Potamodromous	EN	EN	II	III
Ziege	*Pelecus cultratus*	Semi-anadromous	LC	LC	II; IV	III
Vobla	*Rutilus caspicus*	Semi-anadromous	LC	-	-	
Kutum, Black Sea Roach	*Rutilus frisii*	Semi-anadromous	LC	EN	II; IV	III
Taran	*Rutilus heckelii*	Semi-anadromous	LC	LC	-	
Perlfisch	*Rutilus meidingeri*	Potamodromous	EN	EN	-	III
Roach	*Rutilus rutilus*	Potamodromous	LC	LC	-	
Chub	*Squalius cephalus*	Potamodromous	LC	LC	-	
Cavedano chub	*Squalius squalus*	Potamodromous	LC	LC	-	
Baltic vimba	*Vimba vimba*	Semi-anadromous	LC	LC	-	III
Northern pike	*Esox lucius*	Semi-anadromous	LC	LC	-	
Burbot	*Lota lota*	potamodromous	LC	LC	-	
European threespined stickleback	*Gasterosteus aculeatus*	Anadromous	LC	LC	-	
Nine-spined stickleback	*Pungitius pungitius*	(Semi-anadromous)	LC	LC	-	

Lesser grey mullet, Thicklip grey mullet	*Chelon labrosus*	Catadromous	LC	LC	-	
Golden grey mullet	*Liza aurata*	Catadromous	LC	LC	-	
Thinlip mullet	*Liza ramada*	Catadromous	LC	LC	-	
Leaping mullet	*Liza saliens*	Catadromous	LC	LC	-	
Black mullet, Flathead mullet	*Mugil cephalus*	Catadromous	LC	LC	-	
Pond smelt	*Hypomesus olidus*	Anadromous	NA	-	-	
	Osmerus dentex	Anadromous	LC	-	-	
European smelt	*Osmerus eperlanus*	Anadromous	LC	LC	-	
Common goby	*Pomatoschistus microps*	Catadromous	LC	LC	-	III
Sea bass	*Dicentrarchus labrax*	Catadromous	LC	LC	-	
Danube ruffe	*Gymnocephalus baloni*	Potamodromous	LC	LC	II; IV	III
European perch	*Perca fluviatilis*	(Anadromous)	LC	LC	-	
Azoz percarina	*Percarina maeotica*	Anadromous	LC	-	-	
Pike-perch/ Zander	*Sander lucioperca*	Semi-anadromous	LC	LC	-	
	Sander volgensis	Potamodromous	LC	LC	-	III
Caspian lamprey	*Caspiomyzon wagneri*	Anadromous	NT	-	-	
Carpathian lamprey	*Eudontomyzon danfordi*	(Potamodromous)	LC	LC	II	

Ukrainian brook lamprey	***Eudontomyzon mariae***	**(Potamodromous)**	**LC**	**LC**	**II**	**III**
	Eudontomyzon sp. nov. 'migratory'	**Potamodromous**	**EX**	**-**	**II**	
European river lamprey	***Lampetra fluviatilis***	**Anadromous**	**LC**	**LC**	**II; V**	**III**
European brook lamprey	***Lampetra planeri***	**(Potamodromous)**	**LC**	**LC**	**II**	**III**
Arctic lamprey	***Lethenteron camtschaticum***	**Anadromous**	**LC**	**-**	**-**	
Siberian lamprey	***Lethenteron reissneri***	**potamodromous**	**LC**	**-**	**-**	
Sea lamprey	***Petromyzon marinus***	**Anadromous**	**LC**	**LC**	**II**	**III**
Baltic flounder	***Platichthys flesus***	**Catadromous**	**LC**	**LC**	**-**	
European plaice	***Pleuronectes platessa***	**Catadromous**	**LC**	**LC**	**-**	
Baltic cisco, Vendace	***Coregonus albula***	**Anadromous**	**LC**	**LC**	**V**	**III**
Arctic cisco	***Coregonus autumnalis***	**Anadromous**	**LC**	**-**	**V**	
Volkhov whitefish	***Coregonus baerii***	**Potamodromous**	**DD**	**-**	**V**	
Bodensee kilch	***Coregonus gutturosus***	**Potamodromous**	**EX**	**EX**	**V**	**III**
Lavaret/ Baltic whitefish	***Coregonus lavaretus***	**(Anadromous)**	**VU**	**VU**	**V**	**III**
Maraene	***Coregonus maraena***	**Anadromous**	**VU**	**VU**	**II; V**	**III**
Blasik	***Coregonus megalops***	**Potamodromous**	**LC**	**LC**	**V**	**III**

Muksun	*Coregonus muksun*	Anadromous	NA	-	V	
Broad whitefish	*Coregonus nasus*	Potamodromous	NA	-	V	
Houting	*Coregonus oxyrinchus*	Anadromous	EX	EX	V	III
Ob' whitefish	*Coregonus pidschian*	Anadromous	LC	-	V	
Renke	*Coregonus renke*	potamodromous	DD	DD	V	III
Big-eye Mackenzie herring	*Coregonus sardinella*	Semi-anadromous	NA	-	V	
Valaamka, Sandsik	*Coregonus widegreni*	Anadromous	DD	DD	V	III
Danube salmon	*Hucho hucho*	Potamodromous	EN	EN	II; V	III
Kezenoi-am trout	*Salmo ezenami*	Potamodromous	CR	-	-	
Ferox trout	*Salmo ferox*	Potamodromous	DD	DD	-	
Black Sea salmon	*Salmo labrax*	Anadromous	LC	LC	-	
Sonaghen	*Salmo nigripinnis*	Potamodromous	VU	VU	-	
Prespa trout	*Salmo peristericus*	Potamodromous	EN	EN	II	
Atlantic salmon	*Salmo salar*	Anadromous	VU	VU	II; IV	III
Gillaroo	*Salmo stomachicus*	Potamodromous	VU	VU	-	
Atlantic Trout	*Salmo trutta*	Anadromous	LC	LC	-	
Arctic char	*Salvelinus alpinus*	Anadromous	LC	-	-	
Torgoch	*Salvelinus perisii*	Potamodromous	VU	-	-	

Connie, Belorybitsa	***Stenodus leucichthys***	**Anadromous**	**EW**	**-**	**-**	
Nelma	***Stenodus nelma***	**Anadromous**	**LC**	**-**	**-**	
Arctic Grayling	***Thymallus arcticus***	**Potamodromous**	**NA**	**-**	**-**	
European Grayling	***Thymallus thymallus***	**Potamodromous**	**LC**	**LC**	**V**	**III**
Bullhead	***Cottus gobio***	**(Potamodromous)**	**LC**	**LC**	**-**	

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