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Strategy for ecological corridor conservation and restoration in the Danube catchment

Authors and contributions

Main authors (in alphabetic order)

Gertrud **Haidvogl** – *IHG/BOKU* – Austria

Cristina **Munteanu** – *WWF-Romania* – Romania

Ralf **Reinartz** – *IHG/BOKU & Büro für Fischereifragen und Gewässerökologie* – Germany

With contributions of (in alphabetic order of countries)

Borislava **Margaritova**, Maria **Kachamakova**, Phillip **Penchev** – *WWF Bulgaria* – Bulgaria

Zrinka **Mesić** – *Karlovac University of Applied Sciences, Department of Hunting and Nature Conservation* – Croatia

László **Berzi-Nagy**, Attila **Mozsár** – *Research Institute for Fisheries and Aquaculture* – Hungary

Gheorghe **Constantin**, Andreea **Hârceag**, Mihail **Costache**, Doina **Cioacă**, Simona **Pătruț** – *Ministry of Environment, Waters and Forests* – Romania

Andreea **Danciu** – *WWF-Romania* – Romania

Gorčin **Cvijanović**, Mirjana **Lenhardt**, Marija **Smederevac-Lalić** – *University of Belgrade, Institute of Multidisciplinary Research* – Serbia

Ladislav **Pekarik** – *Trnava University, Faculty of Education* – Slovakia

Eva **Horvat**, Polona **Pengal** – *Institute for Ichthyological and Ecological Research* – Slovenia

Reviews and contributions

Peter Gammeltoft, Thomas Hein, Edith Hödl, Petra Repnik, Stefan Schmutz, Karl Schwaiger, Beate Striebel, Franz Wagner

Proofreading Michael Stachowitsch

Layout Astrid Schmidt-Kloiber

Edited by University of Natural Resources and Life Sciences Vienna – BOKU

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Executive summary and policy outlook

Implementation of ecological corridors with a protected network of critical habitats to ensure self-sustaining populations of migratory fish throughout the Danube Basin

MEASURES contributed to securing and restoring the Danube, its tributaries and relevant areas of the Danube Delta and the Black Sea as functioning ecological corridor for migratory fish. The project has documented that numerous of these fish populations are under pressure and have become extremely fragile due to fragmentation and degradation of their migration corridors and their habitats in the Danube River and its tributaries. Certain populations, including most native Danube sturgeon species, are on the verge of collapse as evidenced by the assessments of Danube sturgeon populations by the IUCN.

The decline of the once numerous migratory fish populations in the Danube Basin is the result of the cumulative impact of multiple pressures: interruptions of river continuity and changes in river hydrology and morphology cutting off migration routes, degrading essential habitats and their access routes, pollution and last, but not least, overfishing and poaching.

The project has identified a series of measures (see below) to restore and protect ecological corridors for migratory species, rebuild populations and reduce the risk of their collapse.

Certain pressures on populations (that are not directly linked to the degradation of habitats and migration corridors) were not considered in MEASURES. They will need to be managed through measures other than those identified in this project to achieve the desired target. They include pressure from fishing, including illegal, unreported and unregulated (IUU) fishing, invasive alien species, pollution, climate change and others. Also, for diadromous species, habitats and migration routes in the Black Sea were not considered.

Governance arrangements

Governance arrangements play a major role in the degradation and rehabilitation of conditions for migratory fish populations. The Danube migratory fish populations are subject to the requirement of good ecological status of the EU's Water Framework Directive. Migration corridors and the state of habitats are therefore part of river basin management responsibilities of the competent national authorities. However, important responsibilities with respect to migratory fish species conservation may also lie with other authorities and it is therefore important to clarify the distribution of responsibilities:

- **Ecological corridors** for migratory fish **are** by their very nature also **transboundary** and cannot be managed by national measures alone. The competent authority for transboundary water management in the Danube Basin is the **ICPDR**. It has the powers necessary to mandate **Danube States** to take measures to establish such corridors, including both continuity measures and habitat measures.

- Conservation of migratory fish is at the **crossroads between water management and management of nature and biodiversity**. So far, the competent authorities for the latter have played little role in efforts to restore and conserve migratory fish species in the Danube Basin even though the competent authorities for nature and biodiversity of all countries in the Danube Basin have adopted a European wide Action Plan for sturgeon (PANEUAP) committing them to implementing conservation actions. There is a need for **Danube Basin States** to **clarify** the respective **roles and responsibilities of national nature and water management**.

- There are currently no legal obligations to sustain fish populations by means of **conservation hatcheries** and no clearly defined responsible authorities. Given their nature and purpose, it is proposed that nature protection authorities in the **EU** and **Danube States** concerned should take responsibility for such activities, if appropriate together with fishery authorities.

- There are **sectors outside river basin management** exerting a significant role on the state of migratory fish species in the Danube. There is a need to ensure that policies and their implementation effectively support the recovery and conservation of migratory fish species. The **EU**, the **ICPDR** and the **EU-SDR (PA 06) should take the lead** in developing this support (in particular for sectors with transboundary consequences such as energy, climate and inland waterway transport) with a view to implementation by the relevant competent national authorities.

- Pressure from **fishing in inland waters** has an important impact on some populations, in particular sturgeons. In spite of bans on sturgeon fisheries, poaching remains a problem. Enforcement of fishing bans therefore needs to be effective. This is a task for the **national authorities responsible for fisheries in inland waters**.

- Risk levels for diadromous species in the Danube Basin are also influenced by management of migration **routes and habitats in the sea**. Very little is

currently known about these routes and habitats. The **EU**, competent **national authorities for marine fisheries**, the Black Sea Commission and the **FAO-GFCM** will need to develop this issue with a view to contributing to restoring and conserving sturgeon populations.

Priority measures

The project documents the key technical measures needed to address bottlenecks for the restoration of the ecological corridors which includes in particular

- re-establishing continuity of migration corridors where they have been interrupted, either by removal of barriers or establishment of appropriate conditions or facilities for fish passage
- restoration and maintenance of degraded essential habitats (spawning/juvenile/feeding etc.)
- operation of conservation hatcheries ("ex-situ facilities") for native fish species and conservation stocking to stimulate the rebuilding of populations and help prevent their collapse.

Chapter 5 of this document also identifies a series of supportive measures for the implementation of ecological corridors including population monitoring, legally binding national river basin management and conservation plans, public participation, and increased use of green infrastructure.

The highest and most urgent priority measures needed to establish ecological corridors are:

1 – River continuity

- The Danube River currently has two major continuity blockages at the Iron Gate cutting off the Middle and Upper Danube from the Lower Danube and at Gabčikovo cutting off the Upper Danube from the Middle Danube. Re-establishing fish passage at these two points is of basin-wide interest and will ensure that fish can again migrate all the way from the Black Sea to the Upper Danube.
- The ICPDR and the Danube States are planning to remove a considerable number of obstacles to river continuity in the wider Danube Basin in the 2021-2027 period, based on identified priorities for fish migration. This plan should be implemented, and river continuity maintained as a priority.

2 – Conservation hatcheries ("ex-situ facilities")

Conservation hatcheries are essential to protect populations of critically endangered sturgeon species against collapse. There is no need for hatcheries in all States although multiple hatcheries will be needed to ensure that failures due to exogenous factors do not result in collapse of populations. Putting in place financial support for conservation both for their establishment and for their operation for an extended (multi-decadal) period will be essential due to the time needed for the recovery of sturgeon populations.

Where there is a need to do so conservation hatcheries should be implemented for other species, subject to assessments of the state of populations.

3 – Habitats and corridors

Known previous and current sturgeon habitats have been mapped for the Danube sturgeon species. At the level of the Danube Basin habitat restoration is currently not the subject of specific plans. The ICPDR and Danube States will need to continue the identification of critical habitats, to develop criteria to set priorities for restoration, enhance protection and maintenance of sturgeon and other migratory fish habitats as well as the connecting corridors.

4 – Policy coordination

Enhance cooperation with policies in other areas or sectors to ensure on national and on a basin-wide basis that past and future efforts for protecting ecological corridors are not undermined as a result of policy initiatives in other areas (e.g. hydropower development, inland navigation or flood risk management).

Furthermore, cooperation with relevant competent authorities of Black Sea Countries and the Black Sea Commission has to be enhanced to integrate the marine stages of endangered and vulnerable diadromous species in protection efforts and management plans.

Supportive activities

- Establish basin-wide coordinated population monitoring (for diadromous species including monitoring in the Black Sea) for endangered and vulnerable fish species (**EU**, **ICPDR**, Danube **Basin States**, **Black Sea States**, **FAO-GFCM**) as part of fish monitoring under the Water Framework Directive; include future results in ICPDR TNMN Yearbook, including results from regular and even continuous (automatic) registration of migratory fish at fish migration facilities in Iron Gate, Gabčikovo and other well-chosen strategic bottle necks and results from Danube Delta.

- **Public participation**: information to and dialogue with the public concerned

- **National Activity Plans** to be integrated into National River Basin Management Plans and other relevant management plans should be developed with the cooperation of national nature protection authorities. These Plans as well as the proposed Local Fish Migration Networks initiated to target specific local and regional aspects will be strengthened by the enhanced cooperation with other sectors influencing the conditions for migratory fish. For sturgeon species, the Pan European Action Plan for sturgeon provides a template applicable for national activity plans.

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Technical abstract

The overall goal of this "Strategy for ecological corridor conservation and restoration in the Danube catchment" is to secure the Danube and its tributaries and relevant areas of the Danube Delta and Black Sea as an ecological corridor for migratory fish and to ensure conditions for stable or growing populations. This means in particular to improve ecological corridors with a network of critical habitats to ensure self-sustaining populations of migratory fish throughout the Danube Basin. The Strategy provides the basis for defining the criteria for the ecological corridor, identifying this corridor for the Danube and its tributaries, and developing measures and activities to secure or, when necessary, restore the corridor and its migratory fish populations.

Reaching the overall goal requires following three objectives, which also represent the main components of the ecological corridor for migratory fish (physical connectivity; habitat availability, accessibility and continuity; viable populations).

This Strategy offers a basin-wide framework and guidance for implementation, with an emphasis on national scales. It relates the concept of the ecological corridor to legal frameworks and EU targets as formulated especially in the Water Framework Directive, in the Biodiversity Directive, in the Habitats Directive as well as in more specific directives and strategies such as the Pan-European Action Plan for Sturgeons, in the EU-Strategy for the Danube Region, and in the transboundary agreements established by the International Commission for the Protection of the Danube River (ICPDR; Chapter 2). River continuity interruptions and habitat degradation due to human uses of the Danube River and subsequent technical alterations of hydromorphological

conditions have put severe pressures on migratory fish. Sturgeon species are at the brink of extinction, and many other migratory fish are classified as threatened in at least one of the countries contributing to this strategy. In order to secure and restore the Danube River as an ecological corridor for migratory fish, the MEASURES project aimed at filling major knowledge gaps on habitats of migratory fish and on the conservation of sturgeon species by means of ex-situ measures. Based on the findings, eight Types of Measures (ToM) were developed to achieve improvement. These ToMs form the core of the document (Chapter 5).

Three of the ToMs directly address the management of the Danube River and its tributaries as an ecological corridor. ToM 1 calls for assessing, mitigating or eliminating the negative effects of migration barriers, ToM 2 prompts for the protection and restoration of migratory fish habitats and ToM 3 for green infrastructure for flood management and nature-based solutions for navigation. The latter topic was not dealt with explicitly in MEASURES, but it targets important sectors (i.e. hydropower production, navigation) that can potentially increase already existing pressures on the ecological corridor. ToM 4 strives to secure and support viable populations of migratory fish. Finally, ToM 5 aims to improve and harmonise the monitoring of habitats and fish populations,

Further three of these ToMs are of organisational and supportive nature: ToM 6 is dedicated to developing, on country levels, comprehensive "National Activity Plans for Migratory Fish Species" going beyond the most urgent activities or the topics addressed in MEASURES. ToM 7 proposes to create, establish and facilitate "Local Migratory Fish Networks". Such networks should be composed of stakeholders from different sectors to enable and ensure communication and their activities need to be embedded in established administrative processes and structures. An important basis for these networks was set during the MEASURES project, and future activities can build on these. Finally, ToM 7 suggests activities to improve public participation and support for local migratory fish networks.

The ToMs proposed in this Strategy are of a general nature. National and international priorities are given, among them the highest priorities have (1) re-establishing continuity either by removal of barriers or by building appropriate facilities for fish passage, (2) protect or restore and maintain essential habitats (spawning/juvenile/feeding etc.) of migratory fish, (3) ensure the operation of conservation hatcheries ("ex-situ facilities") for native fish species and conservation stocking to stimulate the rebuilding of populations and help prevent their collapse.

The main addressees for implementation of this strategy are responsible authorities, in particular water management and biodiversity and nature protection authorities. If further developed, Local Migratory Fish Networks can act as support and especially as an exchange platform for implementation. In order to ensure transnational harmonisation of activities, these networks must organise cooperation across the Danube basin well aligned with established management procedures (e.g. WFD). Major events in the Danube basin, e.g. the Annual Fora of the EU-Strategy of the Danube Region or the Danube Day, can be used for physical meetings.

This Strategy proposes indicators to monitor its implementation and defines the expected challenges. Among the most critical points is the voluntary status of this Strategy: making it a legally binding docu-

ment on basin-wide and national levels was neither a target of the MEASURES project, nor would the project duration of three years have offered sufficient time. Accordingly, the implementation of this Strategy depends largely on the cooperation and commitment of the addressed stakeholders. In particular, the Associated Strategic Partners of the MEASURES project can play a major role in this task.

01 Purpose, context and basics of this Strategy

This basin-wide "Strategy for ecological corridor conservation in the Danube catchment" (hereinafter referred to as "Strategy") defines a framework to secure and restore the Danube River and its tributaries as an ecological corridor (eCOR). The focus is on ecological connectivity, habitats of selected migratory fish and their populations. The Strategy compiles existing and new knowledge gained during the MEASURES project and provides guidelines for the national and transnational management of key habitats of migratory fish to achieve an efficient conservation and re-establishment of ecological corridors. The Strategy brings a transnational additional value to the Danube Region because it addresses key objectives and targets of several European directives and strategic documents (see Chapter 1.1).

The document addresses stakeholders concerned by and actively involved in the potential implementation of actions to secure and restore the Danube ecological corridor and migratory fish. This primarily includes various authorities, administrations and "practitioners" who are expected to plan and implement measures to improve the ecological corridor of the Danube and major tributaries for the benefit of the respective migratory fish.

The Strategy considers a timeframe of 7 years, i.e. until 2027, following the revision cycle of relevant management documents, in particular the Danube River Basin Management Plan and national River Basin Management Plans as major tools for implementing the WFD. It does, however, target a long-term situation for migratory fish, especially with regard to sturgeon species be-

Infobox

In a nutshell this Strategy

- is a general framework that compiles the needs to conserve, strengthen and restore the Danube ecological corridor for migratory fish and aligns it with the existing legal framework
- makes the results of MEASURES applicable in practice
- defines Types of Measures and activities
- links aspects on basin and national levels
- harmonises activities across countries
- provides tools and guidance for the local networks for migratory fish, in which the major actors to implement the Strategy on national levels are envisaged to participate
- promotes the role of the ecological corridor and migratory fish

cause of their longevity, late maturation and thus decade-long population recovery.

A main approach of this Strategy is to define Types of Measures on a general level and to provide more specific measures and activities on national scales, which are part of the Annex to this Strategy. Establishing "Local Networks for Migratory Fish" and developing "National Activity Plans for Migratory Fish" are two Types of Measures proposed, which are more of strategic and overarching nature. They can be considered as a means and prerequisite for successful implementation of the other Types of Measures, defining at the same time tasks, criteria or tools for implementation. The implementation of measures should be ensured by integrating them in existing management and policy plans, strategic documents and programmes, national legislation or any relevant public consultations (e.g. EIA, IAWB, EA, SEA procedures), e.g. during revisions or in future documents of this nature.

This Strategy will be disseminated at the policy level in relevant countries and on a transnational level, aiming to raise governmental and political support for embedding ecological corridors and key outputs of the MEASURES project into the future national and international legal and policy instruments (e.g. N2000 management plans, RBMPs).

1.1 European water management and biodiversity legislation and guidelines

The Strategy relates the concept of the ecological corridor to legal frameworks and EU targets such as the EU-Strategy for Biodiversity 2030, the Water Framework Directive (WFD), the Flood Directive (FD), the Habitat Directive (HD), Marine Strategy Framework Directive (MSFD), the new European Green Deal or more Danube specific the European Strategy for the Danube Region.

For example, the new **Biodiversity Strategy for 2030** (BDS) calls in section "Restoring freshwater ecosystems" for greater efforts to restore freshwater ecosystems and the natural functions of rivers in order to achieve the objectives of the Water Framework Dir-

ective. This can be done by removing barriers that prevent the passage of migrating fish or by making them passable, by improving the flow of water and sediments, and by restoring floodplains and wetlands. To help make this a reality, **at least 25,000 km of rivers will be restored into free-flowing rivers by 2030**.

The **Water Framework Directive** requires establishing River Basin Management Plans (RBMP). The RBMPs must describe the (ecological) status of water bodies, identify existing pressures and define measures how to achieve good ecological status or good ecological potential by 2027. In the case of the Danube, the **International Commission for the Protection of the Danube River** (ICPDR) is responsible to set up the transnational Danube-RBMP (DRBMP). ICPDR works based on the Danube River Protection Convention (ICPDR 1994). Based on a pressure analyses for the implementation of the WFD, it defined four Significant Water Management Issues (SWMI): Organic and nutrient pollution, hazardous substances pollution and hydromorphological alteration. According to the draft version of the DRBMP, Update 2021, to be published in December 2021, a fifth SWMI is envisaged to be added, i.e. "Effects of climate change". The establishment of transnational ecological corridors and the reconnection of fish habitats also constitute a major challenge for improving environmental conditions in the DRB as outlined in the relevant plans of the ICPDR (DRBMP 2009, Update 2015, ICPDR Ministerial Declaration 2016; DRBMP Update 2021, to be published in December 2021). Acknowledging the precarious status of sturgeons, ICPDR adopted the **ICPDR Sturgeon Strategy** in 2018 (ICPDR 2018) with the goal of better understanding and highlighting the challenges faced by the Danube's sturgeon in order to add to conservation efforts. It defines meas-

Infobox

Relevant targets of PA4 and PA6
(EU-SDR Action Plan ((SWD(2020) 59) for conserving and restoring the ecological corridor for migratory fish

PA4 - Action 5 Migratory Fish "Promote measures to enable fish migration in the Danube River basin"

- Raise broad public awareness and political commitment for the Danube sturgeons as flagship species for the Danube River basin and for the ecosystems and biodiversity of the Danube River basin as a whole.
- Foster sturgeon conservation activities including protection of habitats, restoration of fish migration routes and ex-situ conservation measures
- Close knowledge gaps concerning monitoring of pressures and planning of measures for fish migration in coordination with PA 6 (Action 3).

PA 6 - Action 3: „Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region":

- Implementation of the Danube-related measures from the Pan-European Action Plan for sturgeon conservation will contribute to their protection and protection of other freshwater species and their habitats.

ures and activities that will support achieving good ecological status or good ecological potential. The scope involves providing an overview of actions and measures considered necessary by sturgeon specialists, in particular from the Danube Sturgeon Task Force working towards securing the survival of sturgeons within the framework of "water competences" of the ICPDR. This involves fostering synergies and cooperation with all national and international players dedicated to sturgeon conservation activities.

The **Habitat Directive** requires habitats designation and management in accordance with the ecological needs of the Annex II species (*Alosa* spp., *Acipenser sturio* relevant for this Strategy) and maintaining the favourable conservation status of Annex V species (*Huso huso*, *Acipenser gueldenstaedtii*, *A. stellatus* and *A. ruthenus* relevant for this Strategy). Moreover, efforts are made at an international level to include additional legally binding targets in the future EU Nature Restoration Law for the sturgeon species currently covered by Annex V. The Strategy developed during the MEASURES project provides measures and activities contributing to the adequate management and restoration of Annex II species habitats, to strengthen sturgeon populations, and anticipates conservation and restoration of sturgeon habitats from EU nature restoration law.

The topic of sturgeon and migratory fish conservation is a very important objective of the EU Strategy for the Danube Region (EU-SDR), for both Priority Areas (PA) 4 (Water Quality) and PA 6 (Biodiversity and Landscapes, Quality of Air and Soils; see Infobox).

While the above-mentioned strategies and strategic documents clearly highlight the need for the restoration of river continuity and its importance for species conservation, the implementation process still needs a harmonised approach at the basin-wide level and commitment on national as well as on transnational levels.

This Strategy is further in line with the **PAN-European Sturgeon Action Plan** contributing to

- Objective 2 – Population structure is actively supported to reverse the decline
- Objective 3 – Sturgeon habitats are protected and restored in key rivers
- Objective 4 – Sturgeon migration (up- and downstream) is secured or facilitated
- Objective 5 – Timely and continuous detection of population sizes and changes in remaining wild stocks.
- Objective 8 – Sturgeons serve as flagship species for healthy river ecosystems. Support from public, political actors, authorities and relevant stakeholders for conservation measures has increased.

1.2 Linkage with relevant projects and initiatives

MEASURES and this Strategy build on the outcomes of STURGENE (DSTF 2016), especially on the extension/adoption of the roadmap and on linking ex-situ facilities. Another major basis development by the Danube Sturgeon Task Force, as an initiative adopted by the EU-SDR Priority Area 6, is the Sturgeon 2020 programme – a programme for the protection and rehabilitation of Danube sturgeons formulated by the Danube Sturgeon Task Force (DSTF). It serves as an important strategic instrument of MEASURES and this Strategy, defining a

comprehensive programme for Danube sturgeon protection.

A crucial aspect for the implementation of an ecological corridor along the DR is also the close linkage to the network of protected areas DANUBEPARKS and the project DANUBEPARKSconnected. The provision of important data from monitoring networks by the ICPDR, Joint Danube Surveys and important links to the existing Danube database provided strategic assistance. Input is also expected from a planned feasibility study for restoring fish migration at the Iron Gate Dams I and II (WePass – opening longitudinal connectivity at the Iron Gates).

Steps in counteracting sturgeon poaching and developing socio-economic measures for fishing communities have been made in two LIFE projects coordinated by WWF AT and covering 4 countries: Serbia, Bulgaria, Romania and Ukraine. The projects closed legal gaps (i.e. no border controls of wildlife trade in Ukraine), improved fishing regulations in Bulgaria and Ukraine, and introduced in January 2019 a new fishing ban for Sterlet in Serbia. The engagement with and training for enforcement authorities resulted in increased control activities, mainly by various police departments, which are now motivated and equipped with the knowledge needed to investigate illegal activities. Trust-building measures with 1000 fishers – the most affected target group of the fishing ban – resulted in fishers sharing valuable information about illegal activities in their communities. Also, business plans for alternative activities to fishing have been developed in order to limit the poaching temptation of sturgeon. Most importantly, the project provided evidence for ongoing illegal fishing and trade in all 4 countries, as 30% of sturgeon products found on the market were illegal and more than 200 cases of illegal fishing were compiled.

1.3 Actors and stakeholders involved in the development of this strategy

The MEASURES project team, national workshops, various actors and stakeholder groups have been involved in developing this Strategy. Basically, stakeholders concerned with the following topics have been addressed: nature protection, biodiversity, river management, flood protection, fishery, transport/navigation, hydropower as well as researchers from fish and river ecology. The types of stakeholder groups and their thematic scope differed in the workshops organised in the MEASURES partner countries (Scherhaufer & Haidvogl 2021). Beyond this, an even wider group of actors and stakeholders shall be concerned with implementing this Strategy.

In national stakeholder workshops organised during the MEASURES project, an important foundation was set to ensure input from and exchange between stakeholders as well as a joint development of future measures and activities (see details in Chapter 5).

1.4 Important topics not covered in detail by this Strategy

The MEASURES project and this Strategy deal mainly with in-situ-, ex-situ-, management-related and policy topics. The following topics are closely connected with but not specifically covered by this Strategy. They are, however, accounted for in closely linked strategic documents and programmes defining the rules and standards in dealing with migratory fish, for example Sturgeon 2020 or the Pan-European Action Plan for Sturgeons under the Bern Convention.

- IUU Fishing (e.g. poaching, bycatch) and working towards a sturgeon catch moratorium or a prolongation thereof (DSTF and WWF CEE activity)

- Acquiring political support for sturgeon conservation

- Capacity building and law enforcement: we will address capacity building for some (creation of national networks during the project) but not all potential activities; MEASURES will not intervene in improving or extending legal documents

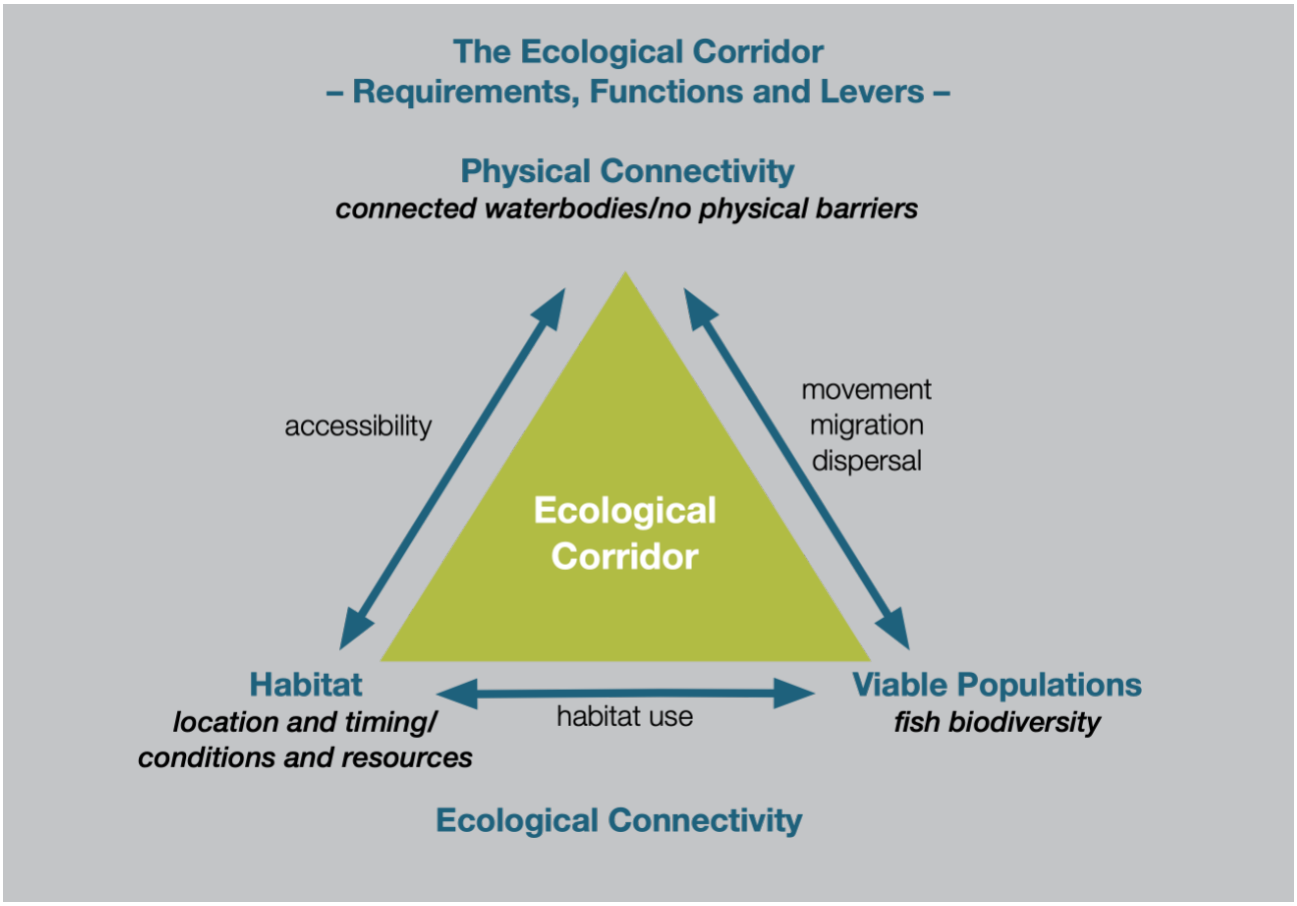
- Socio-economic measures in support of sturgeon conservation

Although the MEASURES Strategy does not contain detailed measures and activities for these topics, they are important elements for its success.

1.5 The ecological corridor for fish

The corridor as an ecological entity belongs to the category of habitat. Importantly, the concept of a catchment or river basin as an ecological corridor encompasses more than the physical waterbody as a migration route or passageway for aquatic organisms. A corridor also includes different categories of habitat, its inherent habitat use and hence also "habitat-using"-fish populations, as well as all processes and exchanges such as information (e.g. behavioural, genetic), turnovers (e.g. energy, biomass, bedload) necessary for the ecological functioning of the system to support viable populations of

Figure 1: Components of the ecological corridor as perceived in this Strategy. The main cornerstones of this triangle also serve as levers for intervention to affect the status and functioning of the eCOR.



native fish and migratory species/ forms in particular (Figure 1).

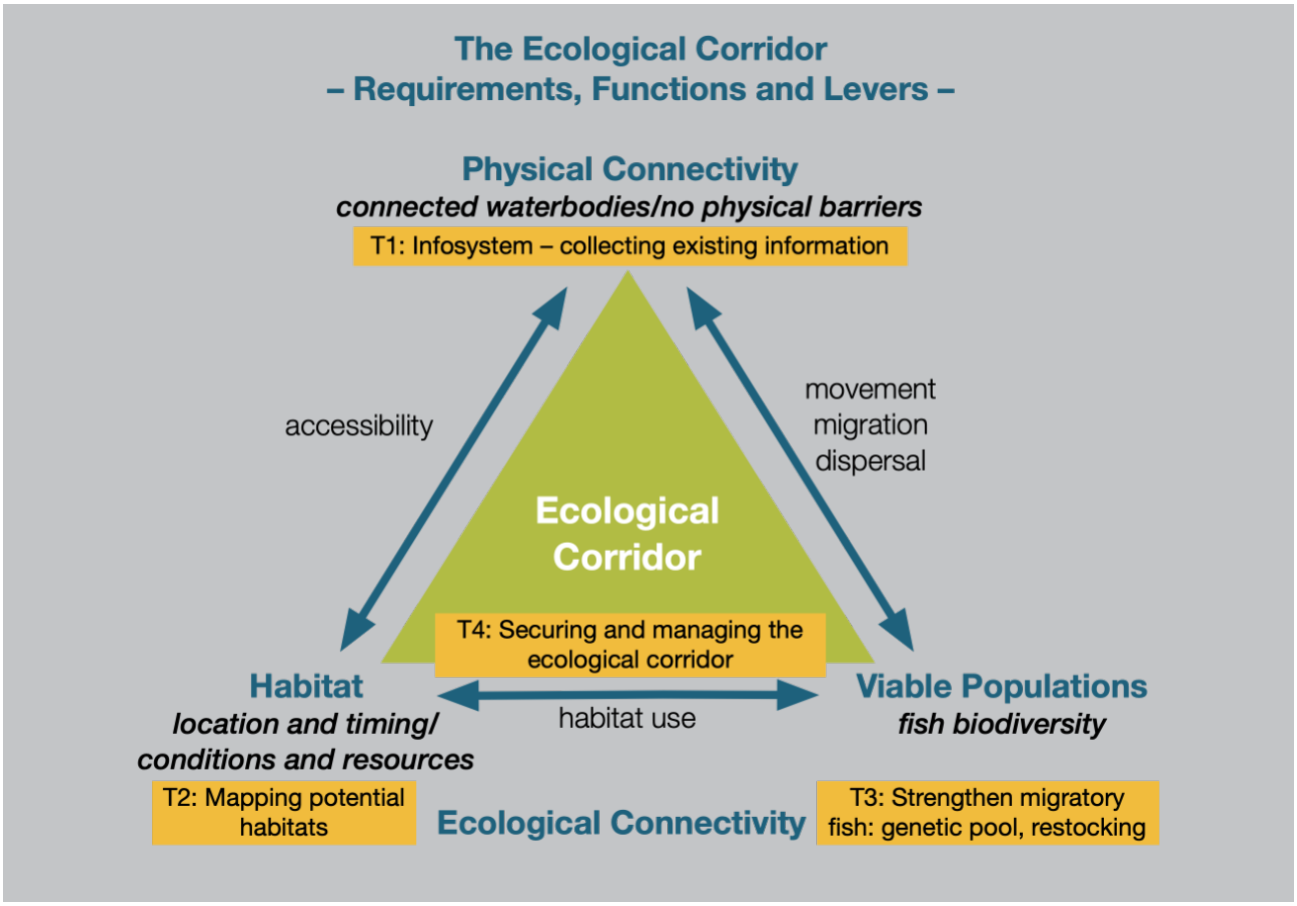
A viable ecological corridor includes the physical connectivity within and between the water bodies of the system, but also the ecological "connectedness" of habitat, habitat use and populations. Thus, ecological connectivity, apart from mere possibility of barriers, also comprises ecological functionality as represented by natural or semi-natural migratory fish habitats that are connected and enable species-specific movements to complete their life cycles as well as gene, energy and matter flow (e.g. DANUBEPARKS 2019).

In this context, habitat is defined as both a location and timing of habitat use, but also as a set of resources and conditions enabling this use. Strategically, this promotes the conservation and restoration of known habitat areas and seasons, as well as the protection of certain conditions of potential habitats within the system.

A well-functioning ecological corridor is an excellent indicator for the ecological integrity and health of a catchment. It incorporates not only river (and corridor) length, but also other relevant basic and more complex factors, conditions and gradients within the system. These include temperature, slope, dispersal patterns, impacts, pressures and biodiversity.

In this document, the Danube River, its tributaries as well as the Black Sea form the ecological corridor at the largest spatial scale. For the purpose of convenient planning and implementation such as conducting mitigation measures, ecological "sub-

Figure 2: Tasks of MEASURES connected to the components of the ecological corridor. T1 – T4: Workpackages of the MEASURES project. T1 addressed all three components of the ecological corridor and provided overarching information.



corridors" with regard to certain topics, areas, pressures and/ or species might be defined and advanced.

1.6 The MEASURES project

The MEASURES project and the results of its workpackages served as a basis for this Strategy. This Strategy makes the findings of the project "Managing and restoring aquatic EcologicAl corridors for migratory fiSh species in the danUbe RivEr baSin" (MEASURES) applicable in practice by transferring the results into measures and activities. Key results such as a harmonised methodology for identifying key habitat (Workpackage T2) as well as conducting ex-situ measures to support endangered populations and to conserve respective gene-pools by the release of juveniles from controlled propagation (Workpackage T3) were considered in this document. A fully customised MEASURES Information System facilitates access to targeted information for experts, decision makers and the general public (Workpackage T1). This Information System also provides valuable information for implementing the Strategy. An analysis of selected management and policy plans underlined the potential but also revealed gaps in existing policies on the national and transnational level (Workpackage T4; Figure 2). In spatial terms, the Danube River and all tributaries are addressed. Note, however, that only the middle and lower Danube and selected sections of tributaries were subject to detailed exemplary field investigations during the MEASURES project.

MEASURES took sturgeons (genera *Acipenser* and *Huso*), shad (*Alosa* spec.) and other migratory fish species such as Barbel (*Barbus barbus*), Vimba Bream (*Vimba vimba*) and Nase (*Chondrostoma nasus*) as flagship species for all migrants of international relevance in the DRB. MEASURES then worked on the options for establishing transnational ecological corridors and supporting populations. This involved connecting (protected) habitats – encompassed by the current network of protected areas along the Danube River and major tributaries – with other critical hotspots for biodiversity, and developing concerted measures related to ex-situ conservation for endangered species.

Dealing with both in-situ- and ex-situ conservation, the MEASURES project and this subsequent Strategy are also strongly biodiversity-related, as the ex-situ concept may be defined as the "*conservation of the components of biological diversity outside their natural habitats*" and in-situ conservation as "*conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticates or cultivated species, in the surroundings where they have developed their distinctive properties*" (Maxted 2013).

02 Overall goal and objectives

The **overall goal** of this Strategy is **to secure the Danube and its tributaries as an ecological corridor for migratory fish and to ensure conditions for stable or growing populations**. It lays the basis for defining the criteria for the ecological corridor, identifying this corridor for the Danube and its tributaries, and developing measures and activities to secure or when necessary restore the corridor and its migratory fish populations.

Reaching the overall goal involves following **three objectives**, which also represent the main identified components of the ecological corridor for migratory fish.

- **Physical connectivity**
- **Habitat availability, accessibility and continuity**
- **Viable populations**

In order to achieve these objectives, this Strategy describes **Types of Measures**, which evolved from the tasks and investigations of the MEASURES project. In detail, the Types of Measures proposed below aim at (1) securing and restoring ecological corridors (physical and ecological connectivity), (2) identifying, securing, restoring and managing habitats of migratory fish and (3) identifying, securing, restoring and managing relevant target populations.

In order to ensure and promote the implementation of the proposed Types of Measures, groups of dedicated stakeholders must be formed on the national level. An important basis for local stakeholder networks was set in national workshops organised during the MEASURES project. Such local networks should (further) develop the implementation of the Types of Measures and activities as defined in this Strategy and en-

sure that topics not addressed here (see Chapter 1.4) are taken up. The local networks should also raise public and political support. Furthermore, they are key for basin-wide exchange and a harmonised implementation of measures and activities.

To **support the implementation** of the Types of Measures described in Chapter 5

- Provides a guideline for Strategy use and implementation
- Prioritises measures and activities as specified in an annex to this document time-wise, e.g. according to their ecological urgency, their complexity or with respect to the working cycles of management and policy documents
- Defines measures and activities, which can be integrated in existing policy and management plans at the local, national and basin-wide scale
- Provides guidance to competent authorities and organisations for existing policy on the national and basin level in order to achieve the goals of relevant European legislation
- Strives at harmonisation and standardisation of measures and activities on and between the local, national and basin-scale
- Accounts for avoiding and, if this is not possible, mitigating adverse effects of infrastructure projects
- Provides a guideline for the evaluation of Strategy success

The following **milestones for developing, implementing and evaluating/monitoring the implementation** were identified according to their chronological sequence:

- Draft Strategy (completed during MEASURES project)
- Stakeholder consultation and feedback (completed during MEASURES project)
- Final Strategy (completed during MEASURES project)
- Incorporation into relevant legislative, policy and management plans (especially after MEASURES)
- Implementation of the Strategy's measures in practice (after MEASURES)
- Collection of feedback from implementation stakeholders (after MEASURES, until 2027)
- Review of Strategy, new draft and Strategy 2.0 (after MEASURES, 2027)

A **timely implementation** of measures in the Danube Basin will contribute significantly to meet the objectives of the **EU Biodiversity Strategy**, of the **EU Water Framework Directive** and the **EU Habitat Directive**.

03 Current status and impacts on the Danube ecological corridor for migratory fish

3.1 The Danube River system

The Danube River is the second largest river in Europe, with a drainage area of 805,000 km2, a length of approximately 2,850 km, and an average discharge of 6,450 m^3/s at its mouth. The whole catchment comprises about 10 % of continental Europe. The Danube crosses or borders ten countries directly (Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Bulgaria, Romania, Republic of Moldova and Ukraine). The whole catchment area touches the territories of 19 different countries, 14 of which are represented in the International Commission for the Protection of the Danube River (ICPDR). A large diversity of landscapes and climates are present within this area.

Geomorphological conditions define three distinct river sections. The upper section (river km 2,850 – 1,790) ranges from Germany to the border of Austria and Slovakia and has an average slope of 40 cm/km, with a high bedload transport capacity. Before regulation, the morphology of the river in this section alternated between canyons with narrow riparian zones (with the river breaking through massive layers of rock) and braided alluvial sections with many side arms and backwaters in large floodplains. This was especially true in Austria. The middle section (rkm 1,790 – 943) is characterised by a major reduction in slope (6 cm/km) and lower bedload transport capacity. This section is separated from the lower section (river km 943 – 0) by a ca. 100-km-long cataract (the "Iron Gate"), where the river cuts through the Carpathian Mountains. In the lower Danube River, the average slope is 3.9 cm/km and the deposition of suspended solids increases significantly (Keckeis & Schiemer 2002).

The Danube River has 9 large tributaries, each with a catchment size above 20,000 km2 and numerous smaller tributaries (Sommerwerk et al. 2009). A functioning connection between the main river and the tributaries is as important as connectivity within the tributaries. These tributaries exhibit a wide range of ecological characteristics from small fast-flowing alpine headwaters up to large, low-gradient lowland rivers. With respect to migratory fish, the focus is mainly on the large and mid-sized streams.

Riverine ecosystems are the lifelines of the Danube River Basin (DRB). They are highly valuable in environmental terms (key ecological corridors). The mainstem Danube and its tributaries are key migration routes for sturgeons and other diadromous species such as shads as well as potamodromous fish, in particular cyprinids like Barbel and Nase but also Sterlet (see below). These species are excellent bio-indicators for the ecological river quality due to their specific needs and inherent habitat changes during their long life-cycles. Especially the long-distance migrating sturgeons represent a natural heritage of the entire Danube Region. Their dramatic decline in the last decades has become an issue of basin-wide importance, documented by the Danube countries and the European Commission.

Simultaneously, riverine ecosystems are lifelines in economic and social terms (e.g. navigation, hydropower, nuclear power plants, flood management, recreation, agriculture, fisheries), which causes increasing pressures related to intense human uses (e.g. pollution, hydromorphological alterations and fragmentation).

Infobox

Pressures of the Danube Ecological Corridor

Main pressures affecting fish biodiversity in the Danube River Basin can generally be grouped into the following major topics, according to Schiemer et al. (2003) and Kováč (2015):

- Water quantity (e.g. water abstraction), quality and river engineering
- River regulation and construction as well as operation of hydropower dams
- Badly managed fisheries (esp. in the case of sturgeons) and a general lack of monitoring
- Invasive species

Main effects of these pressures are:

- Extinction of species
- High number of endangered species
- Qualitative and quantitative decline of fisheries
- Changes in fish composition, for example from habitat specialists (rheophilic and stagnophilic) to eurytopic forms

Most of these pressures are addressed on a basin-wide level because ICPDR has identified Significant Water Management Issues (SWMIs) to account for major pressures in their DRBMPs.

3.2 River continuity and barriers

One very important element of the ecological corridor is an unimpaired longitudinal connectivity. Along the Danube and many tributaries, the implementation of river engineering projects and hydropower use have interrupted river- and habitat continuity (see DRBMP, Update 2015; ICPDR 2015). This hinders aquatic organisms to access essential habitats such as spawning sites and feeding grounds, disrupting their life-cycles and threatening aquatic biodiversity.

Dams and hydropower plants in general represent migration barriers and lead to the fragmentation of habitats for endangered fish. Migratory fish species are particularly affected by this river fragmentation, being unable to move up- and downstream or into tributaries between their required habitats in different parts of the system. The ICPDR counts 1030 continuity interruptions in DRBD rivers with catchment areas >4,000 km2. More than half of these barriers are hydropower dams (614), whereas 284 stem from flood protection and navigation, and 132 fulfil other purposes (e.g. water supply). Together these barriers have a significant and cumulative impact. About 7 % are large dams with water level differences exceeding 15 m, 22 % result in water level differences between 5 and 15 m, and almost half of them cause a water level difference of less than 5 m (all data DRBMP, Update 2015; ICPDR 2015). The latest values will be made available with the DRBMP, Update 2021 in December 2021.

Out of the total 771 water bodies in the DRBD, 317 are affected by barriers for fish migration, of which 54 are passable for fish. 258 water bodies in the DRBD are significantly altered by continuity interruptions that are un-passable for fish species. This represents 33 % of the total number of DRBD water bodies.

Barriers put the function of the Danube River Basin as an ecological corridor at risk by threatening the natural migration patterns of fish and by preventing access to species-specific habitat. According to the DRBMP Update 2015 (ICPDR 2015) only 336 barriers were equipped with a functional fish pass, while at least 670 facilities clearly block fish migration.

This highlights a clear need to foster the connectivity of habitats and promote the establishment of ecological corridors to improve migratory paths of endangered fish species in the DRB. This calls for national actions as well as concerted, transnational cooperation to prevent extirpations and massive biodiversity loss and is thus a major topic of this Strategy.

Pressure mitigation and management of biodiversity requires an efficient monitoring of habitats (including fish migration facilities) and populations because fish are the single most important bioindicator group for assessing the status of ecological integrity.

3.3 Morphological status and habitat conditions

With the implementation of the European Water Framework Directive, the ecological status of surface waters and hence also the status and availability of habitat became an important and mandatory environmental target. This was also because, despite significant improvements in water quality, the trend of declining freshwater biodiversity could not be reversed (FAO 2019).

According to the Fish Migration Foundation, habitat degradation and habitat loss make up over 45 % globally and about 60 % of the overall threat scenario for freshwater migratory fishes in Europe (besides exploit-

ation, invasive species & disease, pollution and climate change) (Deinet et al. 2020).

Based on transnational surveys of the Danube it can be concluded that, in 2015, only 74 out of 771 water bodies were near natural or only slightly altered. A large proportion of the river is moderately (113 water bodies) or extensively to severely (199 water bodies) altered due to various river engineering constructions (DRBMP, ICPDR 2015). No details on the morphological status were available for the remaining water bodies. For the tributaries, case studies and surveys of the morphological conditions are available, but not in the form of a comprehensive overview.

Habitats can be affected by a multitude of impacts such as dams (apart from being mi-

Table 1: Four drivers of habitat change and their effects on sturgeon ecology (from Friedrich et al. 2019; Zeiringer et al. 2018).

Driver	Impact	Effect
Dams	Migration barriers	Upstream migration barrier for spawning migration
		Downstream migration barrier for spent adults
		Downstream migration barrier for juveniles
	Change of downstream habitat	Loss of spawning grounds in vicinity of dam
	Change of habitat upstream-impoundment	Interruption of upstream migration of spawning adults
		Delay of downstream migration of juveniles & increased risk of predation
		Loss of spawning & nursing habitat
		Reduced productivity
	Water abstraction	Water flow modification (e.g. reduction of flow velocity)
		Habitat degradation (e.g. change of substrate patterns, silting of interstitial, reduced water depth and width)
Hydropower operation	Migration barriers & change of habitat	See "Dams"
	Sediment flushing	Loss of spawning & nursing habitat
		Increased mortality of juveniles
		Reduced productivity
	Hydropeaking	Loss of nursing habitat
		Increased mortality of juveniles
		Reduced productivity
	Turbine passage	Increased mortality of adults and juveniles migrating downstream
Changes in Hydromorphology/River engineering	Straightening of river, loss of sidearms & backwaters	Habitat loss
		Reduced productivity
	Deepening of river bed	Habitat loss
	Dredging	Habitat destruction
Water carriage	Navigation	Vessel strikes
	Deepening of river bed	See "Changes in hydromorphology"
	Migration barriers	See "Dams"

gration barriers), infrastructure development, wetland drainage, floodplain disconnection, abstraction of water or sand mining/ gravel extraction. Table 1 lists four exemplary drivers for habitat change and their effects on sturgeon ecology.

Recent studies show that restoration projects aiming at creating static habitat features and characteristics have only limited to no positive effects on aquatic biodiversity. Positive effects may deteriorate even further with time if the dynamic hydromorphological processes creating and renewing habitat structures are not also addressed by restoration measures (FAO 2019).

3.4 Climate change and its effects on the Danube Ecological Corridor

For the Danube River catchment, climate change scenario projections delivered robust trends for the future hydrological runoff regime for the next 30 years. The seasonal stream-flow regime of the Danube and its tributaries is predicted to change considerably, particularly in the tributaries of the middle and lower Danube basin. There is a general trend towards a decrease in summer runoff for the whole Danube basin and for autumn runoff for the middle and lower Danube basin, intensifying the already existing low flow periods. For winter and early spring seasons, an increase in river runoff is projected, while some uncertainties for winter runoff in the Dinaric Alps and the lower Danube basin still exist.

Large changes in the flow regimes of the mainstem river and its tributaries will also shift environmental niches for biota with

Infobox

Climate Change and fish communities

(Daufresne & Boët 2007, Pletterbauer et al. 2014, Stagl & Hattermann 2016)

Effects

- New ecological conditions to which native biota may be adapted poorly or which exceed the tolerances of the native species
- Increased pressure by invasive species

Resulting in

- Abundance shifts in current fish communities
- Replacement of species
- Range shifts within the catchment
- Extirpation of species from the system

Calling for

- Population monitoring
- Evaluation and adaptation of conservation and restoration measures

possible adverse effects for the freshwater ecosystem of river and floodplain and on habitat and populations. These will even exceed the negative effects of anthropogenic influence in disturbed sites (Daufresne & Boët 2007; Pletterbauer et al. 2014; Stagl & Hattermann 2015, 2016).

3.5 Fish biodiversity

The Danube River basin hosts a large variety of fluvial habitats encompassing a rich biodiversity with many unique and endemic species. Fast-flowing mountain streams, wide and slowly flowing lowland rivers, large sand and gravel banks, and in-stream islands host over 100 fish species, many of them in critically endangered status due to habitat- and thus also life-cycle fragmentation.

Freshwater fishes are one of the most important animal groups with regard to zoogeography and aquatic biodiversity because they are confined to drainage systems, which have been described as "*dendritic islands of water surrounded by land, which is in turn bordered by a saltwater barrier*" (Berra 2007).

The Danube basin is a hot spot of biodiversity and has the highest fish biodiversity in Europe (Jungwirth et al. 2014, Sommerwerk et al. 2009). About 20 % of all European species (Kottelat & Freyhof 2007) occur in the Danube drainage as a whole. Importantly, high diversities can also be observed on a local scale due to distinct longitudinal and lateral environmental gradients.

The number of fish species in the Danube River generally increases with distance from its source. No definitive total number of native freshwater species in the basin cannot be provided due to dynamic developments in biology as a science and especially the disciplines of systematics and taxonomy. Kottelat & Freyhof (2009) currently assume a total number of 115 naturally occurring species of freshwater fish for the Danube basin, also taking into account the species from lakes and tributaries, as well as species displaying some tolerance to low salinities from estuarine/ brackish areas of the Delta and the Black Sea. A high native diversity is reported from the Hungarian section, with up to 55 species living in the transition zone between foothills and lowlands. Downstream, the number of species does not change until the lower Danube and the Delta, where fish biodiversity reaches another peak. Today, the impounded sections such as upstream of the Iron Gate dams are dominated by only few eurytopic species (Sommerwerk et al. 2009).

Larger and mid-sized tributaries also show a high fish species diversity. For example, the Slovenian section of the Mura River is currently inhabited by 61 species (fish and lampreys), of which 51 are indigenous (Povž 2016). The Sava River is home to 74 fish and lamprey species, among them 15 considered as non-native (Simonović et al. 2015).

Despite this rich fish biodiversity in the European context, habitat change and degradation negatively affects fish communities in the Danube River system as well. Al-

Table 2: Ecological status classes for all JDS4 sampling sites (Bammer et al. 2021).

	high	good	moderate	poor	bad
Sampling data sets (n)		9	20	9	9
Relative proportion (%)		19.15	42.55	19.15	19.15

though not focussing primarily on migratory species, their populations and forms, the Joint Danube Surveys serve as good indicators for this.

Assessments of fish assemblages along the Danube and in selected tributaries (e.g. Ipel, Drava, Iskar, Jantra) during the Joint Danube Survey in 2019 (JDS4) showed that only 19.2 % (nine out of 47 datasets) delivered a good (fish) ecological status as demanded by the Water Framework Directive. For 42.6% of the sites (20 sampling sites), only a moderate status was documented. Poor or bad status defined 9 sampling sites each (19.2%, Table 2).

Focussing exclusively on the mainstem Danube, the situation becomes even worse, with only 8.5% (4 sites) reaching good status, 46.9% (15 sites) moderate, 21.9% (7 sites) poor and 18.8% (6 sites) bad status.

Relevant with regard to MEASURES and this Strategy are the migratory fish species of the Danube basin, its ecological corridors and thus by logic also the Danube Delta and parts of the Black Sea. Definitions of the term "migratory" for fishes vary. In this case, it includes anadromous and potamodromous species with mandatory migratory life-cycles (e.g. sturgeons and shad), but also species forming both stationary and migratory populations (e.g. Vimba Bream), as well as populations known to regularly include groups or large numbers of migrating individuals (e.g. cyprinids such as Nase and Barbel).

Migratory freshwater fish (including the sturgeons) are disproportionally threatened compared to other groups of fish. Globally, this group has declined by an average of 76%, almost 50% in the two temperate regions of Europe and North America, and most pronounced in Europe with 93% (Deinet et al./World Fish Migration Foundation 2020).

3.6 Examples for migratory fish species of the Danube ecological corridor

(list of species considered in the MEASURES project)

Sixteen species from four different families were considered relevant for the MEASURES project by the partners in the eight countries represented in the project (Austria, Bulgaria, Croatia, Hungary, Romania, Serbia, Slovakia, Slovenia). Note that the description of fish species, especially with respect to their respective conservation status, is limited to these countries. Further areas within the basin – like the German Danube and the Ukrainian part of the Danube Delta – have not been considered and should be integrated in future updates.

The list of fish species dealt with by the MEASURES project comprises members of typical families of migratory fish in the Danube River system. They are exemplary for the whole fish community and the ecological corridor of the Black Sea, the

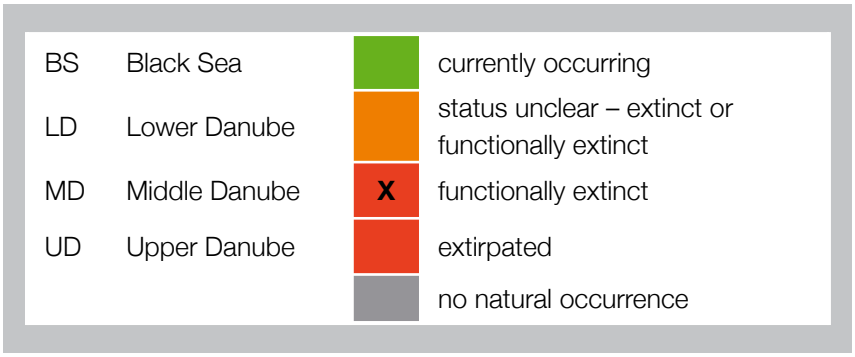


Figure 3: Abbreviations and colour code used for individual fish descriptions. Data for classification compiled by MEASURES partners. All fish images courtesy of the Freshwater and Marine Image Bank, https://digitalcollections.lib.washington.edu

Danube Delta, the mainstem large rivers of the Danube basin and also some higher order tributaries.

They can be differentiated into the two major groups: anadromous migrants utilising marine, estuarine and riverine habitat, and potamodromous species and populations thriving and moving within fresh- and to a certain extent brackish water.

The following figures and tables provide an overview of the families and species, their current distribution and main ecological traits (according to Jungwirth et al. 2003 and EFI+-Consortium 2008), their national consideration for the project, IUCN and national threatened status (Figure 3), and occurrence and use in aquaculture and/ or conservation breeding (Table 3; for details see Apostolos et al. 2020).

Anadromous species

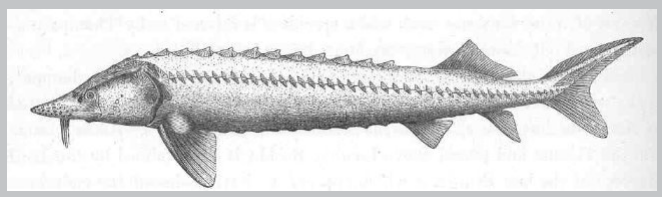
Acipenseridae

Sturgeons are the most iconic migratory fish species in the Danube River system. Three out of four anadromous species still exist in relict populations and are considered by the MEASURES project.

Significance for the ecological corridor: These anadromous species and populations depend on the physical connectivity and habitat continuity within and between the Black Sea, the Danube Delta and the mainstem riverine system of the Danube and its larger tributaries for their spawning migrations. Within this physical corridor, the species need appropriate currents and hard-bottom substrates for spawning and early development. Adults, subadults and juveniles during migration and dispersal need interconnected feeding and nursery areas with high abundances of prey organisms (e.g. fish, molluscs, invertebrates) in the river, the delta and the sea. The sturgeons are important ecological connector species between the open waters of the Black Sea (Beluga Sturgeon), its shallow areas on the continental shelf, the estuarine areas of delta and river, and the mainstem river system including the large tributaries.

The **Beluga** or **Great Sturgeon** (***Huso huso***) is the only true predator among Ponto-Caspian sturgeons, feeding mainly on fish in both fresh- and saltwater. This species once travelled as far as the upper Danube in Bavaria during spawning migration. This species also attains the greatest overall sizes within this family and these waters. Individuals start feeding on fish fry already as juveniles. The status of the Great Sturgeon population is critical, although some juvenile specimens have been caught in recent years as documented by the Danube Delta Reserva Authority and Danube Delta National Institute (DSTF 2020). IUCN classification CR. Habitats Directive Annex V. Bern Convention Annex II. Bonn Convention Annex II. CITES Appendix II.

Beluga or **Great Sturgeon** – ***Huso huso***

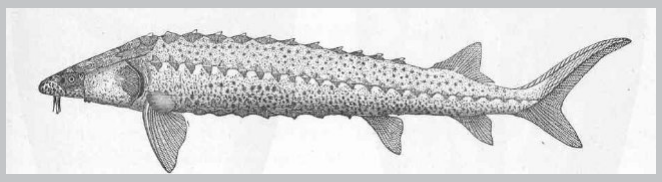


anadromous
eurythermal
rheophilic
piscivorous
lithophilic
rheopar

				main stream
				tributaries
BS	LD	MD	UD	

The **Russian** or **Danube Sturgeon** (***Acipenser gueldenstaedtii***) was once a very abundant species with an upstream migration from the Black Sea regularly reaching spawning sites in Slovakia and Hungary. Today, this species is confined to the Black Sea, the Danube Delta and the mainstem river up to the Iron Gate gorge. In regular monitorings in Romania, no natural reproduction could be documented for 10 years, so that this species is considered to be functionally extinct. IUCN classification CR. Habitats Directive Annex V. Bonn Convention Annex II. CITES Appendix II.

Russian or **Danube Sturgeon** – ***Acipenser gueldenstaedtii***

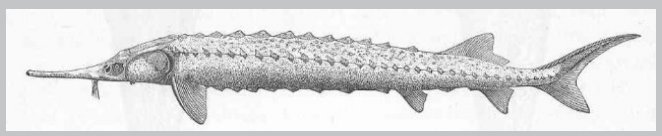


anadromous
eurythermal
rheophilic
benthi-insectivorous
lithopelagophilic
rheopar

X	X			main stream
X				tributaries
BS	LD	MD	UD	

The **Stellate** or **Starry Sturgeon** (***Acipenser stellatus***) regularly migrated as far as Hungary. Its populations have also suffered from overexploitation and loss of habitat. IUCN classification CR. Habitats Directive Annex V. Bern Convention Annex II. Bonn Convention Annex II. CITES Appendix II.

Stellate or **Starry Sturgeon** – ***Acipenser stellatus***



anadromous
eurythermal
rheophilic
benthi-insectivorous
lithopelagophilic
rheopar

				main stream
				tributaries
BS	LD	MD	UD	

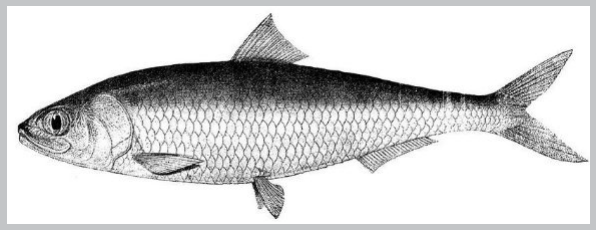
Clupeidae

The members of the **herring** family or **river herrings** inhabit both sides of the Atlantic in North America and Europe, around the Mediterranean Sea, as well as in the Black Sea and Caspian Sea basins and the Balkans.

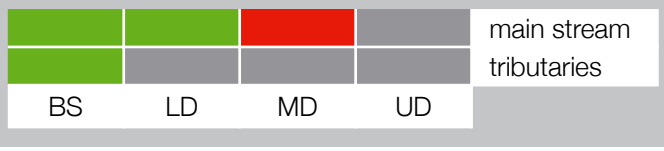
Significance for the ecological corridor: These anadromous species and populations depend on the physical connectivity and habitat continuity within and between the Black Sea, the Danube Delta and the mainstem Danube for their spawning migrations. Within this physical corridor, the species need appropriate currents and sites for spawning and early development. Adults, subadults and juveniles during migration and dispersal need interconnected feeding and nursery areas with high abundances of prey organisms (e.g. fish, molluscs, invertebrates) in the river, the delta and the sea. The shad are important ecological connector species between the shallow, well-lit areas of the continental shelf, the estuarine areas of delta and river and the mainstem river system.

In previous centuries, the **Pontic Shad** (***Alosa immaculata***) migrated from the Black Sea up to 1,425 km in the Danube River for spawning (as far as Bezdan in Serbia), before the blocking of the main migration route at the Iron Gate gorge. This species and its life-cycle may be characterised as marine pelagic-neritic and anadromous. Migrations include the continental shelf of the Black Sea at depths between 3 and 90 m, spawning in freshwater, and important feeding areas for adults in the sea and brackish areas in the delta estuary for juveniles. It feeds on small fishes and crustaceans. IUCN classification VU. Habitats Directive Annex II and V. Bern Convention Annex III and Revised Annex I of Resolution 6 (1998).

Pontic Shad – *Alosa immaculata*



anadromous
eurythermal
rheophilic
insectivorous
pelagophilic
rheopar

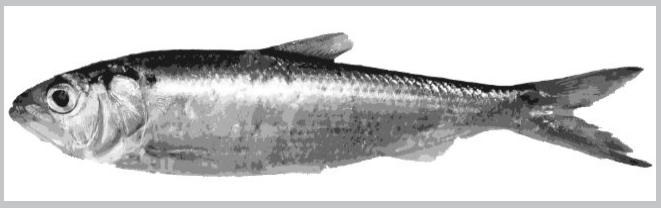


The **Black Sea Shad** (***Alosa tanaica***) has a similar life-cycle, yet did not migrate as far upstream as the Pontic Shad. IUCN classification LC. Habitats Directive Annex II and V. Bern Convention Revised Annex I of Resolution 6 (1998).

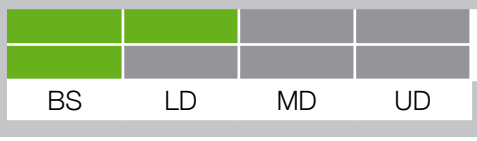
There are recent indications that shad individuals might be distributed even further, as eDNA-sampling has documented *Alosa* sp. at rkm 954 and in the tributary Russenski Lom in Ruse (Bulgaria). There are also new records of the Black Sea

Shad upstream of the Iron Gate dam at rkm 871 from 2016 and 2019, potentially indicating the passing of ship locks for this species (unpublished data Lenhardt; Cokan et al. 2021).

Black Sea Shad – *Alosa tanaica*



anadromous
eurythermal
rheophilic
insectivorous
pelagophilic
rheopar

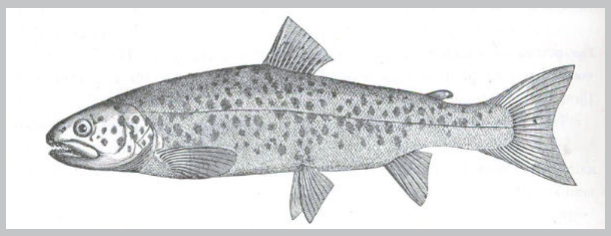


Salmonidae

The **Black Sea Salmon** (***Salmo labrax***) forms anadromous as well as potamodromous riverine and lacustrine populations throughout its range. Little is known about the ecology of the anadromous form in the Black Sea-Danube River system.

Significance for the ecological corridor: The Black Sea Salmon is an important ecological connector species between the Black Sea, the delta and the freshwater river system as far up as to the rhithral stretches of streams in hills and mountains. IUCN classification LC.

Black Sea Salmon – *Salmo labrax*



anadromous
stenothermal
rheophilic
insecti-piscivorous
lithophilic
rheopar

ecology of Danube anadromous ecotype largely unknown

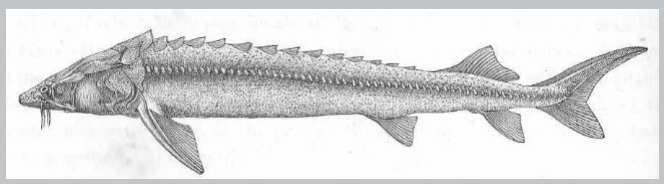
Potamodromous species

Acipenseridae

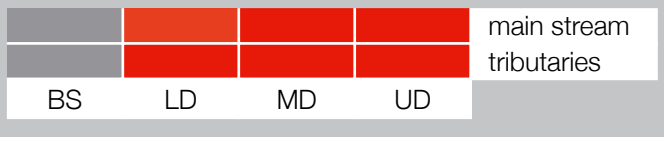
There are also potamodromous members of the **sturgeon** family in the system. Significance for the ecological corridor: These species and populations depend on the physical connectivity and habitat continuity within and between the different parts of the Danube River system up to the Barbel zone. Within this physical corridor, the species need appropriate currents and sites for spawning and early development. Adults, subadults and juveniles during migration and dispersal need interconnected feeding and nursing areas with high abundances of prey organisms (e.g. fish, molluscs, invertebrates) in the river. These potamodromous sturgeons are important ecological connector species between the different parts of the Danube River system.

The **Ship Sturgeon** (***Acipenser nudiventris***) forms both anadromous and potamodromous populations throughout its range. For the Danube system population only a potamodromous life-cycle has been reported. This is the most elusive sturgeon species of the Danube River system. It is considered extinct and only few individuals were reported in the past decades. Sightings were documented in the mainstem Danube, but also upstream in larger tributaries as far as the Barbel zone. (Current) IUCN classification CR; however, according to the new IUCN classification by the Sturgeon Specialist Group this species has to be considered extinct in the Danube River (pers. comm. Ludwig 2020; IUCN letter to EU Commissioner). Habitats Directive Annex V. Bonn Convention Annex II. CITES Appendix II.

Ship Sturgeon – *Acipenser nudiventris*

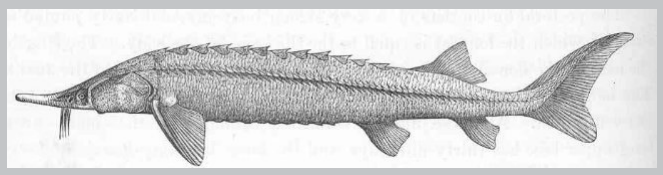


potamodromous
eurythermal
rheophilic
benthi-insectivorous
lithopelagophilic
rheopar



The **Sterlet** (***Acipenser ruthenus***) was once the sturgeon species with the widest distribution within the Danube River system, besides the anadromous Beluga. Today, its distribution has become patchy, especially in the upper and middle Danube basins. Current IUCN classification VU; however, according to the newest IUCN classification by the Sturgeon Specialist Group, this species has to be considered endangered in the Danube River (IUCN letter to EU Commissioner). Annex V. Bern Convention Annex III. Bonn Convention Annex II. CITES Appendix II.

Sterlet – *Acipenser ruthenus*



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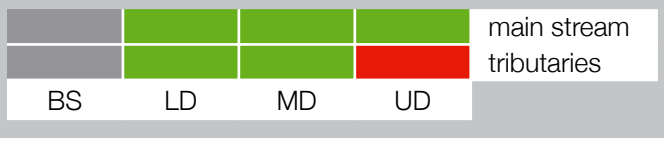
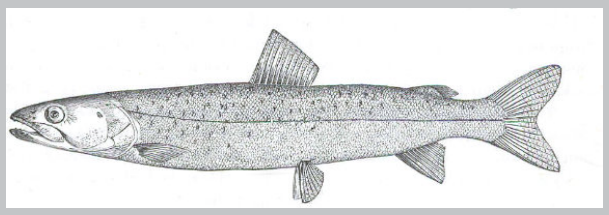


Salmonidae

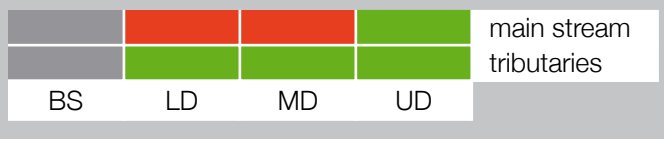
The **Danube Salmon** (***Hucho hucho***) once possibly formed a meta-population in the Danube River system, with individual populations or population segments utilising habitat in the Danube mainstem system and tributaries from the Barbel as far up as the Grayling zone. IUCN classification EN. Habitats Directive Annex II and V. Bern Convention Annex III and Revised Annex I of Resolution 6 (1998).

Significance for the ecological corridor: The Danube Salmon is an important ecological connector species within the Danube River system and its tributaries because it is known to thrive in deep stretches of larger rivers with fast currents and high abundances of fish as potential prey, but also needs access to spawning sites in the Grayling zone.

Danube Salmon – *Hucho hucho*



potamodromous
stenothermal
rheophilic
piscivorous
lithophilic
rheopar



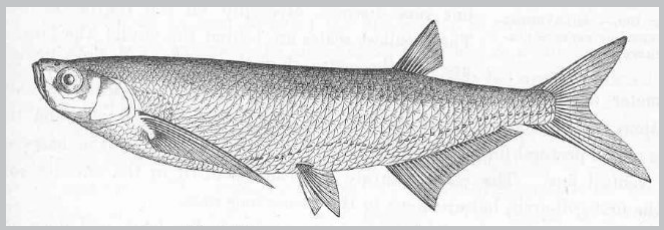
Cyprinidae

The **carp family** or **Cyprinidae** comprises numerous species, ecological preferences and life-cycle strategies in the Danube River system. Ecologically healthy stretches of the Danube River system down to the Delta are characterised by a high variety of cyprinid species at different life stages from various ecological and reproductive guilds. These species utilise a wide variety of naturally occurring ecological situations and may travel long distances between suitable habitat for spawning and feeding in the main river, but also use various lateral ecological situations like different order tributaries, furcations and sidearms, connected and disconnected backwaters, as well as other types of water bodies in the floodplain.

Significance for the ecological corridor: The cyprinids in their different life stages are important indicator and connector species of and for the availability and accessibility of a variety of natural riverine and estuarine habitat in the system.

The **Ziege** or **Sabre Carp** (***Pelecus cultratus***) is a species that requires lateral structures such as backwaters and tributaries during its life-cycle. It inhabits large lowland rivers, impoundments and littoral lakes, where it is known to migrate long distances for feeding. IUCN classification LC. Habitats Directive Annex II and V. Bern Convention Annex II and Revised Annex I of Resolution 6 (1998).

Ziege or **Sabre Carp** – ***Pelecus cultratus***



potamodromous
eurythermal
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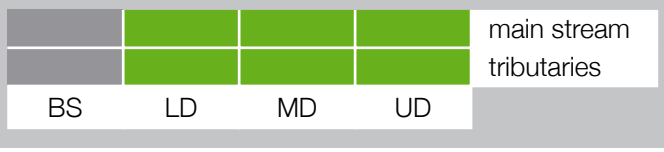
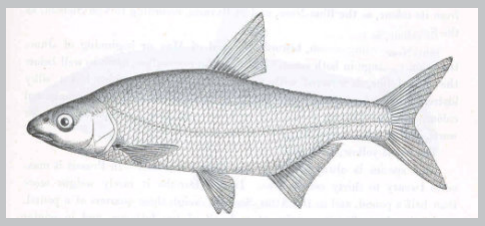
planktivorous
pelagophilic
limnopar

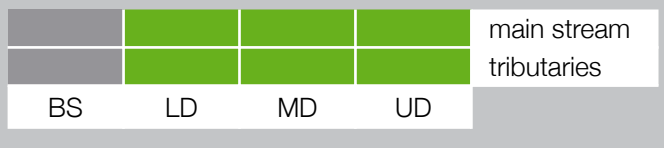


The **Vimba Bream** (***Vimba vimba***) is a potamodromous species, yet includes some semi-anadromous populations that migrate upstream from brackish into freshwater rivers for spawning. Nonetheless, rheophilic freshwater populations also exist in the Danube. Similarly to Nase, they spawn in schools in fast-moving stretches with stony or gravelly substrate and little vegetation. IUCN classification LC. Bern Convention Annex III.

Vimba Bream – *Vimba vimba*

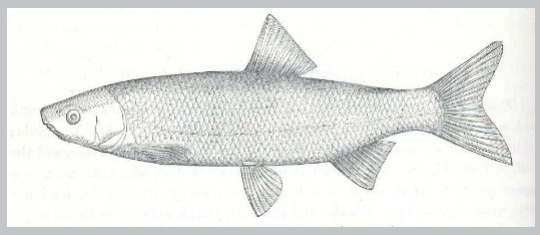


potamodromous
eurythermal
rheophilic
insecti-omnivorous
lithophilic
rheopar



The **Nase** (***Chondrostoma nasus***) is a rheophilic species inhabiting the deeper water of the Barbel and Grayling zones of main rivers with swift currents, often in groups in the backwaters of shore structures or in rocky outcrops. It dwells near the bottom, where it grazes on (diatom) algae, aquatic plants and invertebrates. It spawns in fast-flowing stretches over gravelly or stony substrates, but may also migrate into smaller tributaries for reproduction. IUCN classification LC. Bern Convention Annex III.

Nase – *Chondrostoma nasus*



potamodromous
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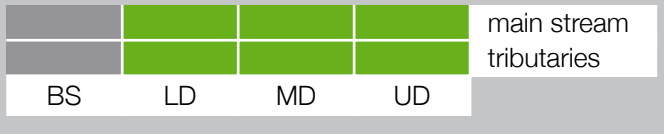
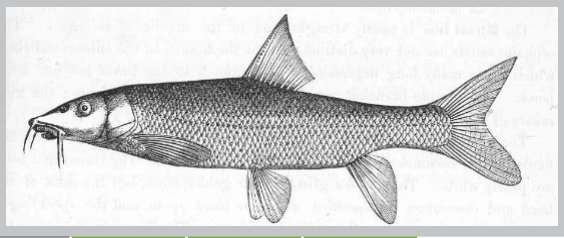
detriti-herbivorous
lithophilic
rheopar

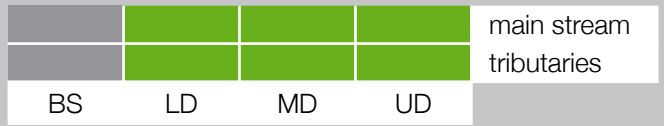


The **Barbel** (***Barbus barbus***) is a rheophilic bottom dweller and lives in fast-flowing rivers with gravel or stone substrates, which it also uses for spawning. IUCN classification LC. Habitats Directive Annex V.

Barbel – *Barbus barbus*

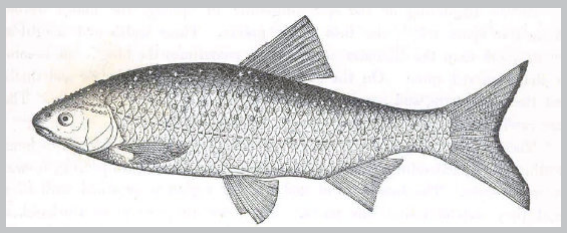


potamodromous
eurythermal
rheophilic
insectivorous
lithophilic
rheopar



Little is known about the ecology of the **Cactus Roach** (***Rutilus virgo***), a rheophilic species inhabiting medium to large rivers near the bottom. IUCN classification LC. Habitats Directive Annex II (under the name *R. pigus*).

Cactus Roach – *Rutilus virgo*



potamodromous
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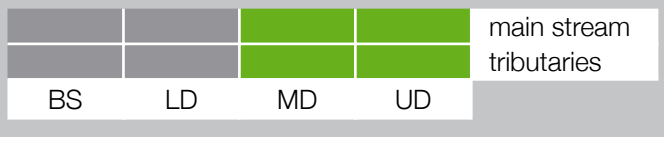
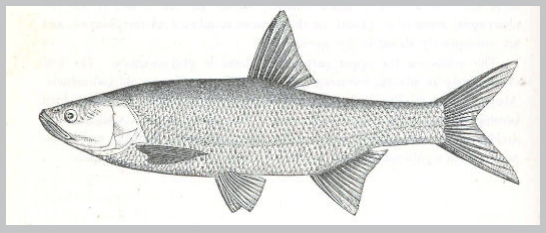
rheophilic
insectivorous
phytophilic
rheopar

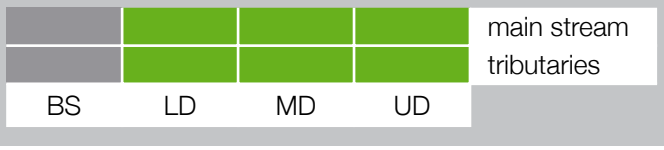


The **Asp** (***Leuciscus aspius***) inhabits lakes, larger rivers and especially the lower reaches and estuaries. Adults dwell at the surface of fast-flowing stretches, where they prey on fish. As juveniles, this species needs connected backwaters to complete its life-cycle. IUCN classification LC. Habitats Directive Annex II and V. Bern Convention Annex III.

Asp – *Leuciscus aspius*

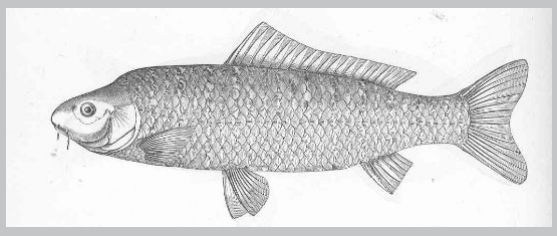


potamodromous
eurythermal
rheophilic
piscivorous
lithophilic
rheopar



The **Danube Carp** (***Cyprinus carpio carpio***) in the project context refers to the original wild variety of this species present in the Danube River system, not the various domesticated strains. Its current status remains unclear. IUCN classification Danube River subpopulation CR.

Danube Carp – *Cyprinus carpio carpio*



potamodromous
eurythermal
eurytopic
omnivorous
phytophilic
limnopar

BS LD MD UD

Legend Table 3 (next page):
grey cells: the species has not been worked on by partners from the respective country
green cells: (officially known) ex-situ initiatives/experience and/or release of specimens in the wild for population support of the respective species
yellow cells: (officially known) captive broodstock of respective species used solely for commercial purposes or aquaculture

Conservation categories/status:
EX – extinct; RE – regionally extinct; CR – critically endangered; EN – endangered; VU – vulnerable; LC – least concern
SI: R – rare species/potentially endangered (ranljiva vrsta); E – endangered species/significantly endangered (ogrožena vrsta oziroma prizadeta vrsta)
HR: SP – strictly protected species; TBC – temporary ban on catch; MLC – minimal length for catch
RS: SPWS – strictly protected in the wild; PWS – protected wild species; PBC – permanent ban on catch; TBC – temporary ban on catch; MLC – minimal length for catch; DC - daily catch
HU: HP – highly protected, P – protected; NC – not protected, yet not catchable; N – not protected
SK: RE – regionally extinct

Table 3: Overview of migratory fish species considered by partners in the MEASURES project and their national conservation status al. 2018).

Country	RO	BG	RS	HR	SI	HU	SK	AT
Anadromous species								
Acipenseridae								
Beluga / Great Sturgeon (*Huso huso*)	CR	CR	CR SPWS PBC	RE SP		very rare P	RE	
Russian / Danube Sturgeon (*Acipenser gueldenstaedtii*)	CR	CR	CR SPWS PBC	RE SP	RE	very rare P	CR	
Stellate Sturgeon (*A. stellatus*)	CR	CR	CR SPWS PBC	RE SP		very rare P	RE	
Clupeidae								
Pontic Shad (*Alosa immaculata*)	VU	VU	CR SPWS PBC	DD SP		P		
Black Sea Shad (*A. tanaica*)	LC		DD SPWS PBC	SP				
Salmonidae								
Black Sea Salmon (*Salmo labrax*)		CR	not observed	not evaluated			RE	
Potamodromous species								
Acipenseridae								
Ship Sturgeon (*A. nudiventris*)	CR	EX	CR SPWS PBC	RE SP		very rare P	RE	
Sterlet (*A. ruthenus*)	VU	EN	VU PWS PBC	VU TBC MLC	R	stable NC	LC	CR
Cyprinidae								
Ziege, Sabre Carp (*Pelecus cultratus*)		VU		DD	R			NT
Vimba Bream (*Vimba vimba*)		N/A	LC PWS TBC MLC	VU	E	N	NT	VU
Nase (*Chondrostoma nasus*)		N/A	LC PWS TBC MLC DC	LC	E	N	NT	NT
Barbel (*Barbus barbus*)	LC	VU	LC PWS TBC MLC DC	LC MLC	E	N	LC	NT
Cactus Roach (*Rutilus virgo*)			LC PWS TBC MLC DC	NT (as *R. pigus*)	E	rare P	VU	EN
Asp (*Leuciscus aspius*)	LC	VU	LC PWS TBC MLC DC	VU TBC MLC	E	N	LC	EN
Danube Carp (*Cyprinus carpio carpio*)		CR	LC PWS TBC MLC DC	EN TBC MLC	E	N	CR	EN
Salmonidae								
Danube salmon (*Hucho hucho*)	EN		EN PWS TBC MLC DC	EN TBC	E	very rare HP	VU	EN

04 Input for the Strategy – main results of MEASURES

During the MEASURES project, valuable basic information about the Danube system as an ecological corridor was created. Some key results are briefly described below. Further details can be found in the deliverables and outputs for the specific workpackages as noted in the respective sections.

4.1 Mapping of potential habitats of selected migratory fish and habitat verification

During MEASURES, potential and actual spawning, nursery, feeding, wintering and resting habitats of selected migratory species were identified. For potential habitat identification, various sources such as reports, field protocols or museum specimens were used. Furthermore, maps, aerial and satellite images, bathymetry maps and field measurements were analysed based on ecological traits of species. The actual use of potential habitats was verified by analysing the results of (previous) field surveys and using different types of sampling gear as well as tagging. The task considered the fish species mentioned in Chapter 3 but the focus was on sturgeon habitats (Figure 4). For all fish species, about 2,200 locations in the Danube and selected tributaries were identified as potential habitat, of which roughly 50 % could be confirmed as actual habitat during MEASURES field work and previous surveys.

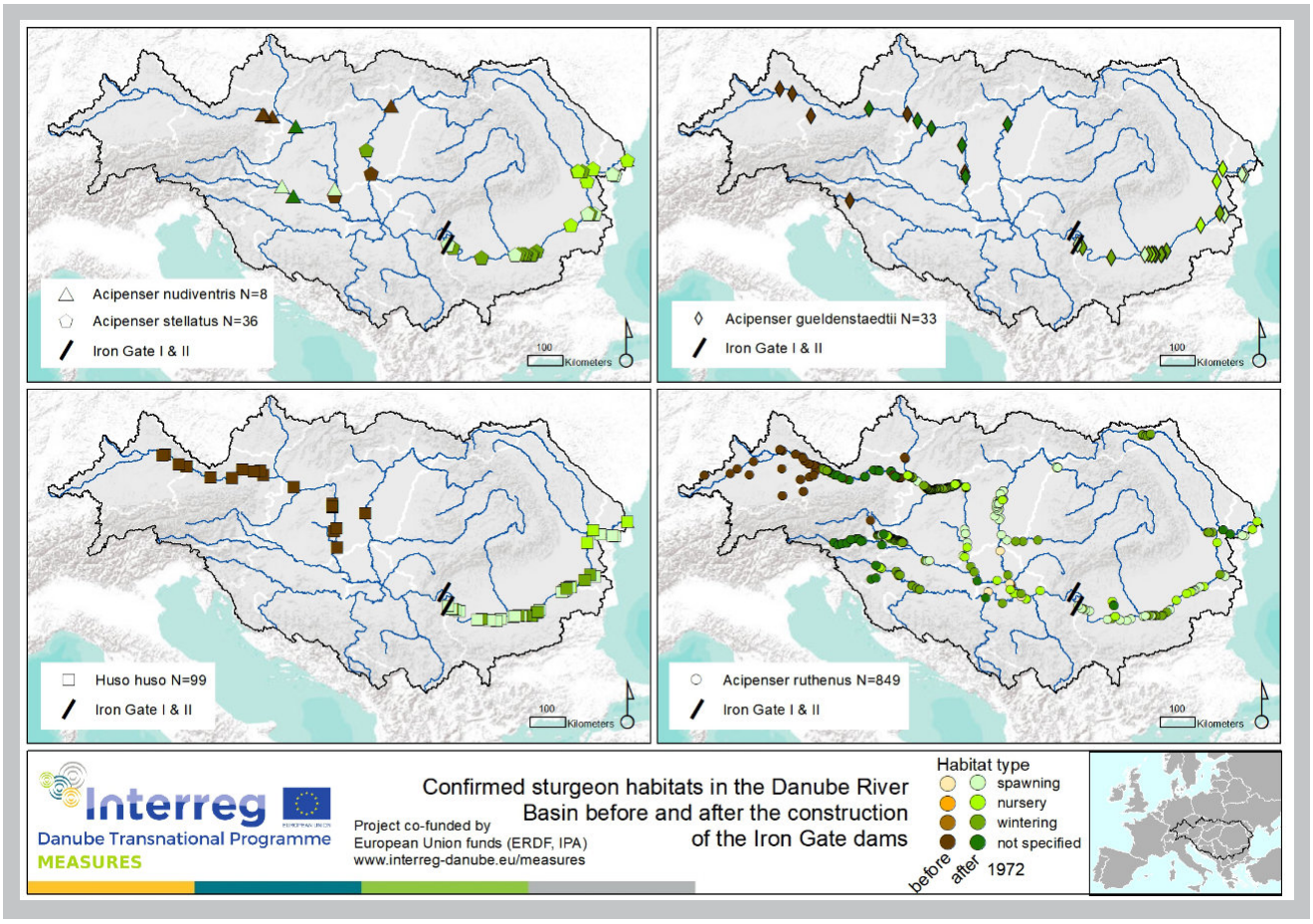
Despite the huge joint effort enabled in the MEASURES project, knowledge gaps in terms of migratory fish habitats still exist. For example, a compilation of existing knowledge about habitat conditions on national scales is missing and is an important subject of future work.

Some further information is available in Chapter 3.3 and in Cokan et al. (2021).

The MEASURES project accomplished pilot actions following a harmonised methodology. Accordingly, neither the list of potential habitats nor that of actually used habitats is complete. With respect to obtaining an overview on the status or distribution of the respective species on the scale of the Danube region, one can conclude that:

- During MEASURES, selected sections of the Danube and tributaries were investigated. Thus, knowledge gaps remain in terms of potential and actually used habitats and habitat types for sturgeon and shad species in the Danube River and in investigated tributary sections. These gaps are even larger for the potamodromous species.
- Only a small proportion of potential habitats were sampled during the MEASURES pilot actions in the field. Thus, the presence of the targeted migratory fish species could be documented for only a fraction of these habitats. The reasons for this include sampling techniques and timing or too small fish populations.
- More information and knowledge on habitat, especially for the potamodromous species, might potentially be retrieved by examining further documents not readily available through ordinary sources, e.g. in grey literature.
- The results, in combination with the analysis of Management and Policy Plans, strategic documents and

Figure 4: Confirmed Sturgeon Habitats in the Danube River Basin before and after the Construction of the Iron Gate dams.



infrastructure projects, lead to the conclusion that many actual and potential habitat sites lack sufficient protection.

- Finally, migration barriers must be made passable in order to secure a functional ecological corridor and to ensure the completion of the life-cycle of migratory fish and a sufficient exchange within the gene pool.

4.2 Securing native stocks and further developing monitoring methods of critically threatened Danube sturgeons

Securing native populations of Danube sturgeon is a pressing task because the number of individuals for most species is very low and the ship sturgeon is probably extinct in the Danube catchment. The information on Russian sturgeons gathered over the last decade shows that this species is functionally extinct in the Danube Basin and the neighbouring Black Sea.

Thus, collecting and keeping of broodstock and its genetic analysis are a major prerequisite for re-establishing and supporting sturgeon populations. Ex-situ gene stocks keep viable sturgeon populations under safe and controlled conditions over longer periods. These captive populations harbour broodfish, which are frequently propagated for continuous releases of genetically suitable juveniles that are fit for survival in the wild to strengthen the remaining wild sturgeon populations or for reintroduction into formerly inhabited parts of the system.

The state of the art and knowledge was compiled in a "genetic manual", which provides among others a protocol for broodstock management and breeding (Reinartz 2021).

eDNA-markers for monitoring purposes were identified for Sterlet (*Acipenser ruthenus*) and Ship Sturgeon (*A. nudiventris*) and tested at selected Danube sites. No proof of *A. nudiventris* was possible, but the presence of Stellate sturgeon, for which an eDNA marker was already available, and Sterlet could be documented based on eDNA sampling.

4.3 Stocking Sterlet and Russian Sturgeon in the middle and lower Danube

The highly endangered status of sturgeon species in the Danube calls for both long-term and short-term actions. The stocking of wild populations with additional individuals serves as a short-term supporting effort for the sturgeon species. In this context, the ex-situ gene stocks referred to above are a backbone of the revitalisation measures, but to ensure an ideal genetic background, broodfish collection and subsequent genetic analyses are necessary as well.

In the MEASURES project, two sturgeon species were selected for these activities based on their relatively well accessible populations. Sterlet broodstock was collected in Hungary (10 specimens) in 2020 and transported to NAIK-HAKI, which maintains a Sterlet gene stock in Hungary. As Russian Sturgeon broodstock was not available in Hungary, 3,000 fertilised eggs were purchased in Romania in 2020 and transported to BOKU for further rearing. Surviving fry were split between BOKU and NAIK-HAKI to share the responsibility and infrastructural demand of rearing them to larger sizes.

During stocking events, artificially reared individuals are released back into their natural habitat. In Hungary, Sterlet juveniles

were released in 2019 (5,000 specimens) and in 2020 (1,500 specimens). Furthermore, 24,000 Sterlet fry were released into the tributaries of Danube in 2020. Russian Sturgeons were available in Romania in adequate numbers. DDNI purchased 1-year old juveniles each year from 2019 to 2020 for Russian Sturgeon stocking events. The release of Russian Sturgeon juveniles took place in Romania in 2019 (1,500 individuals), spring 2020 (300 individuals), and in autumn 2020 (700 individuals). All released fish of both species (except the fry due to their small size) were tagged with internal tags or external anchor tags. This method enables tracking released individuals over longer periods. For tagging, Floy external T-bar anchor Tags (Sterlet) as well as Coded Wire Tags, PIT tags or Floy external T-bar anchor Tags (Russian Sturgeon) were used. These tags include ID numbers to identify the released fish if caught at another location in the future.

So far, individuals from both species were recaptured and reported. The experimental Sterlet restocking proved to be successful: 17 tagged Sterlet specimens released in Baja and Ercsi in April 2019 were caught in Serbia a few weeks after release. Furthermore, nine specimens released in Baja in May 2020 were caught in Serbia in July 2020. This suggests the rapid spread of the restocked fish. On one hand, this decreases their chance to be preyed, on the other hand it makes their recapture challenging. Therefore, the citizen recapture data play a crucial role in evaluating the success of restocking. During the recapture survey in Hungary, some Sterlet specimens were caught but none of them were tagged. Russian Sturgeon were reported in the Chilia branch (near Vilkovo) in October 2020.

4.4 Building ex-situ facilities

In order to create adequate and specialised ex-situ facilities to rear Danube sturgeon species for conservation and restocking, a scouting mission was conducted in 2019 by BOKU and NAIK-HAKI. Existing sturgeon ex-situ gene stocks and their diverse infrastructural environments were visited in Italy ("Pisano Dossi" fishfarm, "Storioni Ticino" fishfarm, "Naviglio" fishfarm) and Germany ("Landesforschungsanstalt für Landwirtschaft und Fischerei" in Born/ Mecklenburg-Vorpommern, "Leibniz-Institute for Gewasserökologie und Binnenfischerei" in Berlin). The discussions focused on the types of water supply (semi-flow-through or RAS systems), filtering and cleaning, feeding and lighting conditions as well as on biological characteristics related to the size of a well-functioning ex-situ system. The advantages and disadvantages of the systems were analysed. The conclusion was that different sturgeon species require various environmental settings – there is no general "sturgeon" setting.

With respect to ex-situ activities and (re-) stocking, one can summarise that conservation restocking has to integrate genetic perspectives. This is because the genetic integrity of recipient native populations is a keystone factor for long-term, sustainable conservation. The genetic survey of the sterlet gene bank in NAIK HAKI consisted of wild caught specimens and revealed similarity between the gene bank-originated sterlets and wild caught (from different locations and rivers) specimens in terms of population genetics. The conclusion is that there is dominance of heterozygotes in the studied populations, including the sterlet broodstock in the gene bank of HAKI. The minimal broodstock size and the mating design are crucial in ex-situ conservation, and both must be based on the genetic traits. This makes a genetic manual, which provides a

guide for the genotype-based ex-situ conservation. very important for ex-situ conservation. The broodstock holding and preparation of specimens for propagation are also crucial steps of ex-situ conservation.

4.5 Migratory fish in national and international strategic documents, management and policy plans

During the MEASURES project (WP T4), national, regional and international management and policy plans as well as strategy documents from the policy sectors "conservation", "sustainable development", "fisheries", "river basin management", "flood risk management" along with "transport" and "hydropower" were analysed. For the project and the Strategy, it was of special interest whether these documents considered rivers and especially the Danube River system as ecological corridors for migratory fish. The analysis yielded the following insights:

- The situation differs significantly between the countries in the Danube basin.
- The conservation of migratory fish species, the protection of their habitats, and rivers as ecological corridors are covered in most of the countries in their conservation policy, biodiversity targets or river management, particularly with regard to the implementation of WFD requirements.
- Plans on the national or regional level often do not explicitly target the ecological corridor and migratory fish species. This reflects the often general nature of national conservation and biodiversity policy plans rather than a disregard towards migratory fish and the ecological corridor.
- The most important kind of plans in the different countries for migratory fish and the ecological corridor were the official River Basin Management Plans. Such Plans integrated these two ecological aspects in assessments and subsequently encompassed them in habitat protection or mitigation and restoration measures.
- Management and policy plans are a major tool to balance the (often conflicting) interests of different river uses and respective stakeholders.

Apart from documenting the acknowledgement of the ecological corridor and its populations of migratory fish in official documents, however, the analysis also revealed a number of deficits that remain to be dealt with.

- In general, major deficits in the management and policy plans with regard to the ecological corridor and migratory fish relate to their implementation. This is a common situation for conservation and restoration targets. Weaknesses in the implementation of a plan can refer to incomplete implementation in practice, failure to update plans according to changed policies and laws, as well as missing legal approval.
- Several strategies or plans need a more explicit integration of habitat and fish protection or restoration measures. The targets of different types of legal, strategic and management documents are conflicting and must be better harmonised.
- Often, weaknesses or deficits stem from accompanying “soft” measures. These include financing and training the necessary personnel, missing funding

possibilities (esp. for measures to directly protect fish and habitats or restore them) or insufficient integration of concerned stakeholders.

- Data related to migratory fish from various types of monitoring to adequately assess the current ecological conditions are lacking in practice. This is the case even if such assessments are required by e.g. nature and biodiversity protection plans or river basin management.

- In some cases, baseline data are available, but subsequent effects of protection and restoration measures or infrastructure constructions are not monitored and documented.

- Progress in implementing protection and restoration measures is often not appropriate to reach the ecological targets given in specific documents.

- In some countries, migratory fish are not considered in the ecological status assessment according to the WFD.

- Current water-engineering measures pose an ongoing threat to the ecological corridor and migratory fish in all countries.

- Some ongoing infrastructure projects (navigation, hydropower) should be (re-)evaluated and their negative effects on the ecological corridor should be estimated.

- Future river-engineering projects for navigation and hydropower production, currently being implemented or planned, will further negatively impact the ecological corridor and migratory fish populations in many countries (see above, subchapter on pressures).

- Additional threats outside the geographical and thematic scope of the MEASURES project affect migratory fish populations and/or the ecological corridor. In the lower Danube, for example, IUU fishery poses a serious threat and increases the extinction risk, especially for sturgeons.

- These deficits call for a structured response in theory and practice. This includes amending the respective official documents and strategies, as well as implementing the proposed measures of the Strategy. Within its framework, this will have to include the development of specific regional, national and international Action Plans for the Danube ecological corridor and migratory fish species. Similar approaches and efforts for e.g. sturgeon species (Acipenseridae) or the Danube Salmon/Huchen (*Hucho hucho*) can serve as best practice examples. Finally, it is an indispensable for future policy and management to respect minimum ecological requirements as well as to identify and promote compromise solutions.

4.6 Integration of and exchange with national stakeholders

Integrating stakeholders was a core interest of the MEASURES project. The aim was to achieve a shared understanding of the project results and implementation at the national and basin level, as well as to improve the implementation process, feedback and data collection. The framework of stakeholder integration was defined in a "stakeholder strategy". This was agreed among MEASURES partners at the beginning of the project and a list of important stakeholder organisations was compiled. The stakeholder groups considered were related

to nature protection/conservation/restoration, river management/flood protection, fishery, hydropower, navigation and agriculture/forestry.

People from national and regional authorities and administrations, private and public enterprises, as well as NGOs, associations and researchers were invited to participate in three workshops which were organised during MEASURES in each partner country. Stakeholders were thus able to follow the progress of the project, to interact and discuss results, and in particular to contribute to the development of a harmonised Strategy and its implementation. Comparing the results of the national workshops in the eight MEASURES partner countries reveals substantial differences in terms of cooperation between stakeholders from different thematic areas as well as institutional levels.

In each country, the respective local stakeholder group forms a pool of potential members for the Local Migratory Fish Networks, which shall play a key role in the implementation of this Strategy.

4.7 Conclusions from the main results of MEASURES – what is needed to improve the Danube ecological corridor and migratory fish

The Types of Measures proposed in this Strategy focus on the above-described results of the MEASURES project and in particular on the identified gaps. Based on these, eight Types of Measures were defined. They are described in the following chapter on a general level, and national and transnational priorities are highlighted. More details for the specific activities can be found in the annex.

In order to integrate those threats for the ecological corridor and migratory fish species that were not taken into account in MEASURES (e.g. fisheries), we propose as an overarching and first type of measure to develop "National Activity Plans for Migratory Fish Species". The stakeholder workshops organised during MEASURES can be taken as a basis for developing such National Activity Plans.

Table 4 depicts how the conclusions, i.e. the identified gaps and necessities as identified by MEASURES, translate into implementable measures and activities of the Strategy.

Table 4: How identified gaps and necessities translate into Types of Measures.

Gaps and necessities identified	Type of Measure
• In most countries, no consistent and stable organisational structures to protect and restore the ecological corridor and migratory fish exist	• Creating, establishing and facilitating "Local Migratory Fish Networks"
• Overarching strategy for the ecological corridor and migratory fish missing in most countries	• Developing and implementing comprehensive National Activity Plans for Migratory Fish Species
• Gaps in monitoring of actual/potential habitats; mapping	• Monitoring of migratory fish species and their habitats
• Conservation of habitats often not secured by policy and management plans • Habitats threatened by infrastructure projects • Verification if implementation of management and policy plans are effective often missing	• Protecting and restoring habitats of migratory fish
• Impacts and passability of individual migration barriers are only partly known, especially in the Danube tributaries	• Assessing and mitigating or eliminating effects of migration barriers on the ecological corridor
• Up to now, there are no state-of-the-art ex-situ programmes and facilities functioning according to standards agreed upon by the scientific community • The population structure and natural reproduction of endangered fish species needs to be supported by releases of juveniles from controlled and conservation-oriented propagation	• Securing and supporting populations of sturgeon species and other migratory fish
• Establishment of local networks fails among others due to lack of funding, interest conflicts among different water use sectors but also public perception	• Improving public participation and support for local migratory fish networks
• Infrastructure built for flood protection, navigation or hydropower use is still often purely technical and continues to threaten the ecological corridor and migratory fish	• Developing, promoting and implementing green infrastructure for flood management and nature-based solutions for navigation

05 Types of Measures suggested for implementation

The **overall goal** of this Strategy is to **secure the Danube and its tributaries as an ecological corridor for migratory fish and to ensure conditions for stable or growing fish populations**. This Strategy lays the basis for defining the criteria for the ecological corridor, identifying this corridor for the Danube and its tributaries, and developing measures and activities to secure or when necessary restore the corridor and its migratory fish populations.

Reaching the overall goal involves pursuing **three objectives**, which also represent the main identified components of the ecological corridor for migratory fish.

- **Physical connectivity**
- **Habitat availability, accessibility and continuity**
- **Viable populations**

MEASURES has documented that numerous Danube migratory fish populations are under pressure and have become extremely fragile due to fragmentation of their migration corridors and their habitats. Certain populations, including most native Danube sturgeon species, are on the verge of collapse as evidenced by the IUCN assessments of Danube sturgeon populations.

The decline of the once numerous migratory fish populations in the Danube Basin is the result of the cumulative impact of multiple pressures: interruptions of river continuity and changes in river hydrology and morphology that cut off migration routes, degrading essential habitats and their access routes, pollution and last, but not least, overfishing.

The MEASURES project has identified a series of measures (see below) to restore and protect ecological corridors for migrat-

ory species, rebuild populations and reduce the risk of their collapse. Certain pressures on populations (i.e. those not directly linked to the degradation of habitats and migration corridors) were not considered in the project. They will need to be managed through measures other than those identified here. They include pressure from fishing, including IUU fishing, invasive alien species and pollution. Moreover, for diadromous species, habitats and migration routes in the Black Sea were not considered.

Governance arrangements play a major role in the degradation of conditions for migratory fish populations. The Danube ecological corridor – integrating migratory fish populations – is subject to the requirement of good ecological status of the EU's Water Framework Directive. Migration corridors and the state of habitats are therefore part of the river basin management responsibilities of the competent national authorities. Importantly, however, key responsibilities with respect to migratory fish species conservation lie with other authorities. This makes it necessary to clarify the distribution of responsibilities (see Chapter 6). Concerned authorities and institutions as main users of this Strategy should link up with other sectors to also tackle these topics. This would help to avoid any doubling of conservational effort and to take advantage of existing synergies. Enhanced cooperation with policies in other areas or sectors ensures, on a basin-wide basis, that restored continuity and habitats are maintained and that the many undegraded corridors and habitats do not deteriorate as a result of policy initiatives in other sectors (e.g. hydropower development, inland navigation or flood risk management). Furthermore, cooperation with Black Sea Countries and the Black Sea Commission must be enhanced to develop the protection of endangered and vulnerable diadromous species.

In order to transfer the results of MEASURES into practice, this Strategy provides guidance to competent authorities and stakeholders on the national level and basin level (for example to ICPDR) for existing policy. This pertains especially to considering further river basin management planning as well as nature or biodiversity protection in order to achieve the objectives of relevant European legislation, as given as context in Chapter 1 of this document.

The Strategy documents the key technical measures needed to address bottlenecks for the restoration of the ecological corridors. In particular, this includes

- re-establishing continuity of migration corridors where they have been interrupted, either by removing barriers or establishing appropriate conditions or facilities for fish passage
- restoration and maintenance of degraded essential habitats (spawning / juvenile / feeding etc.)
- operation of conservation hatcheries ("ex-situ facilities") for native fish species and restocking to stimulate the rebuilding of populations and help prevent their collapse

In order to achieve these overarching targets, eight Types of Measures (ToM) are described (Figure 5). Five of these ToMs relate directly to conservation and restoration of the three main pillars of the ecological corridor:

- **ToM 1** – Mitigate or remediate the ecological impact of migration barriers (relates to pillar "connectivity" of the eCor)

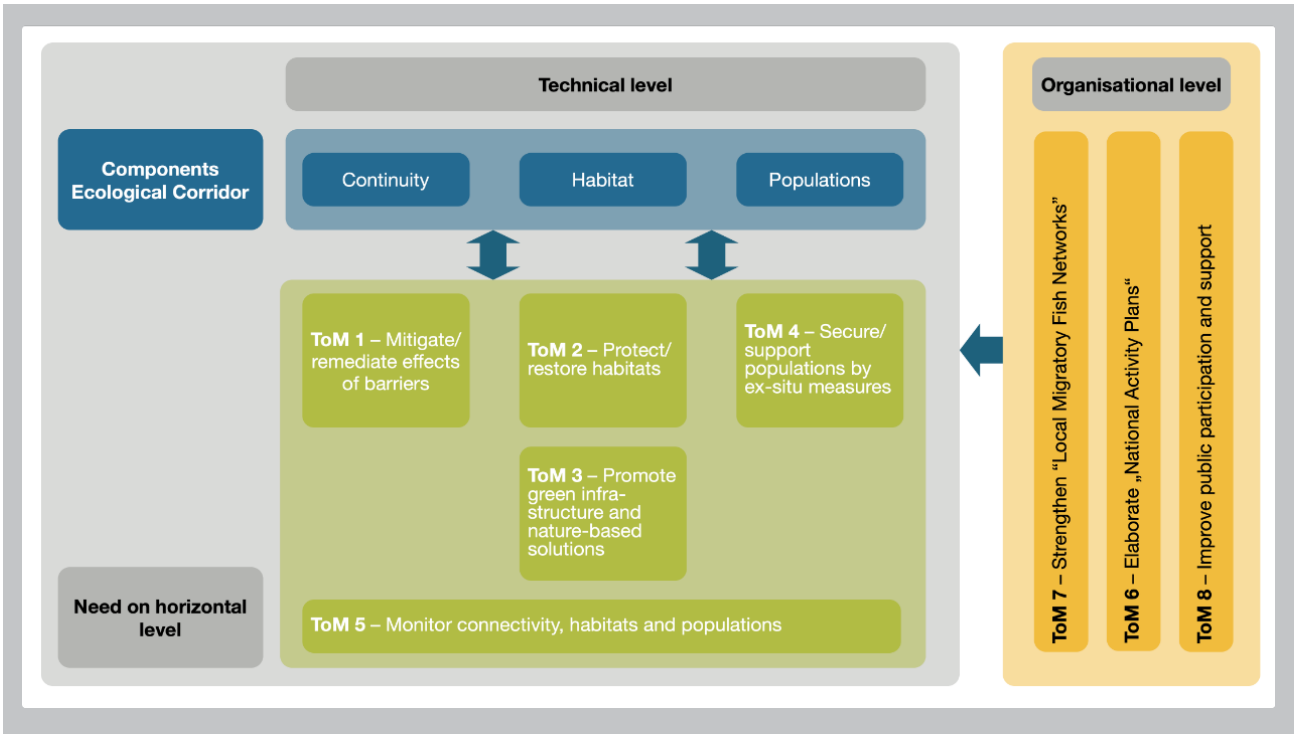


Figure 5: The eight Types of Measures proposed in this Strategy and their link to the three main pillars of the ecological corridor.

- ToM 2 – Protect and restore habitats of migratory fish (relates to pillar "habitat" of the eCor)
- ToM 3 – Implement green infrastructure and nature-based solutions (relates to pillar "habitat" of the eCor)
- ToM 4 – Secure and support populations with ex-situ measures (relates to pillar "populations" of the eCor)
- ToM 5 – Monitor connectivity, habitats and populations (relates to all three pillars of the eCor)

Three further ToMs are of organisational nature and support the implementation of the above-mentioned ToMs:

- ToM 6 – Develop comprehensive National Activity Plans for migratory fish species
- ToM 7 – Establish or further develop Local Migratory Fish Networks
- ToM 8 – Improve public participation and support for Local Migratory Fish Networks

On the level of ToMs, all have high priority because all three pillars of the ecological corridor are severely negatively affected by human pressures. Importantly, only when all three pillars are addressed equally can the overall goal be achieved. Also, on the organisational level, the three ToMs are equally important to support the successful implementation of the technical ToMs.

Table 5 presents an overview of the ToMs. The following subchapters define, for every Type of Measure, the targets, the rationale based on the MEASURES project, as well as addressees and transnational and national priorities. The transnational and the national levels are closely linked for ecological

Table 5: Overview of the Types of Measures (ToM). The objectives refer (1) to the elements of the ecological corridor (eCOR) addressed by a ToM; (2) the main outputs of the MEASURES project providing further details (these documents can be found at: http://www.interregdanube.eu/approved-projects/measures/outputs); (3) important transnational strategic documents.

Type of measure	Target	Rationale ***Key actions***
ToM 1. Mitigate or remediate the effects of migration barriers on the ecological corridor	Restore physical continuity and ensure fish passage at barriers	Barriers obstruct the movement and migration of populations and individuals. *Prevent new barriers, remove barriers, build fish passages*
ToM 2. Protect and restore habitats of migratory fish	Ensure habitat availability, accessibility and ecological continuity	Habitat protection and restoration is indispensable to improve the ecological corridor and ensure migratory fish conservation. As a prerequisite, good monitoring programmes should be in place. *Identify habitat, restore and/or protect*
ToM 3. Develop, promote and implement green infrastructure for flood management and nature-based solutions for navigation	Ensure the protection and enhancement of nature and natural processes	Green infrastructure promotes methods to ensure e.g. flood management and navigation using integration of natural and nature-based methods. *Develop and implement green infrastructure solutions*
ToM 4. Secure and support populations of sturgeon species and other migratory fish by ex-situ measures	Save populations from extinction	Endangered populations need protection in the wild, but sometimes also supportive ex-situ measures for rebuilding population structure by releasing genetically suitable individuals from controlled propagation. *Develop and implement ex-situ programmes and facilities*
ToM 5. Monitor migratory fish populations and their habitats	Ensure knowledge-based management of populations and habitat	Research and monitoring of populations and habitat is the basic prerequisite for any kind of population and habitat management. *Develop and implement habitat and population monitoring*

Type of measure	1. Objective (reference to ecological corridor/eCOR) 2. MEASURES project results 3. Strategic documents	Spatial scale – international, basin wide, national
ToM 1.	1. All three elements of the eCOR 2. None 3. EU-Biodiversity Strategy, Pan-European Action Plan for Sturgeons, EU-SDR Action Plan, DRBMP (ICPDR)	• Basin-wide • Pilot activities on regional and national levels
ToM 2.	1. Habitat 2. Habitat map, habitat manual 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan, DRBMP (ICPDR)	• Sub-basin, if required by natural distribution or reintroduction • Local
ToM 3.	1. All three elements of the eCOR 2. None 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan, DRBMP (ICPDR), Flood directive, WFD	• Sub-basin • Local
ToM 4.	1. Viable populations 2. Ex-situ manual 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan	• Basin-wide • Transnational because populations cross borders • Sub-basin, if required by natural distribution or reintroduction • Mirror- or twinning facilities in different parts of the basin possible, if close coordination is ensured
ToM 5.	1. Viable populations, habitat 2. Habitat map, habitat manual 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan, DRBMP (ICPDR), Habitats Directive (reporting)	• Basin-wide • Pilot activities on regional and national levels

Table 5: continued.

Type of measure	Target	Rationale ***Key actions***
ToM 6. Elaborate comprehensive National Activity Plans for Migratory Fish Species	Ensure applicability of the Strategy also on national level	National Activity Plans for Migratory Fish Species (NAP-MFS) ensure consistent targets, activities and implementation on the national scale. They allow accounting for local and regional specifics and for international and basin-wide targets and framework conditions. NAP-MFS should be built based on the MEASURES Strategy. In MEASURES partner countries, local networks can initiate the NAP-MFS. *Develop NAP-MFS*
ToM 7. Strengthen "Local Migratory Fish Networks"	Create structures of expertise and responsibility	Well-established Local Migratory Fish Networks ensure the implementation of the NAP-MFS. They can act as exchange and cooperation platforms on basin-wide or even European scale. They allow a timely reaction if framework conditions change. *Establish LMFNs and a basin-wide overarching structure*
ToM 8. Improve public participation and support for Local Migratory Fish Networks	Ensure public, stakeholder and political support	Public participation directly engages the public in decision-making and gives full consideration to public input in making that decision. With increasing complexity of subjects, such as eCor conservation and restoration, the variety of interests emerging from different kinds of organisations increases. *Create public, stakeholder and political awareness*

Type of measure	1. Objective (reference to ecological corridor/eCOR) 2. MEASURES project results 3. Strategic documents	Spatial scale – international, basin wide, national
ToM 6.	1. All three elements of the eCOR 2. Outputs on "Developing stakeholder cooperation" and "Lessons learned from MEASURES" 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan	• National • Basin-wide harmonisation
ToM 7.	1. All three elements of the eCOR 2. Outputs on "Developing stakeholder cooperation" and "Lessons learned from MEASURES" 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan	• National • Basin-wide harmonisation and exchange
ToM 8.	1. All three elements of the eCOR 2. Stakeholder list, external communication strategy 3. Pan-European Action Plan for Sturgeons, EU-SDR Action Plan	• Transnational • National

as well as for management and organisational reasons. For example, fish ecological requirements with respect to migration do not follow national boundaries. Furthermore, monitoring requires harmonisation and exchange on the basin level. To monitor sturgeon habitats, a joint methodology has been identified and tested during the MEASURES project in selected sections of the Danube and certain tributaries. On the national scales, adaptations might be necessary and monitoring must be implemented. For every ToM a more detailed description is given along with a list of useful milestones to assess the implementation process and its progress. Finally, the connex is shown to the EU-SAP, the EU-SDR (PAs 4 and 6) and the DRBMP as a major existing strategic documents. An annex to this document provides specific examples for national activities as identified during three rounds of national workshops in every MEASURES partner country.

ToM 1 Mitigate or remediate the effects of migration barriers on the ecological corridor

Target • Restore physical continuity and ensure fish passage at barriers.

Rationale • Barriers obstruct the movement and migration of populations and individuals. Although MEASURES did not investigate connectivity and migration barriers in detail, there is sufficient knowledge on the detrimental effect of such obstacles on migratory fish. As "connectivity" is one of the three main pillars of an ecological corridor (hereafter eCor), re-opening migration routes is an indispensable component of eCor protection and restoration.

Principal addressees • Competent authorities and institutions involved in water management on basin and national levels, especially authorities responsible for establishing the River Basin Management Plans; hydropower companies.

National and international priorities

- Restore connectivity at the Iron Gates and Gabčikovo dams to re-establish migration between the lower and middle and towards the upper Danube
- Restore connectivity at other obstacles blocking access to habitats already identified as critical by MEASURE
- Initiate pilot activities to remove barriers in tributaries
- Restore long cross-border stretches of physical and ecological continuity (see also ToM 2)
- Monitor the functionality of existing fish passages, especially on the chain of hydropower plants on the Sava River
- Implement multifunctional passage solutions (e.g. as passage and habitat) whenever possible
- Ensure migration in impounded sections
- Ensure nation-wide barrier identification and passability surveys to develop barrier catalogues, including identification of obsolete barriers to be removed
- In order to support the implementation of these priorities
- Allocate appropriate resources to ensure that ecological corridors in large rivers work well for upstream migration as well as for downstream migration, where a number of open questions still require clarification

- Allocate appropriate funds for the remediation of these obstacles to fish migration
- Put in place appropriate administrative mechanisms (such as periodic reporting in Annual meetings of ICPDR on progress) to ensure no further delays in remediation
- Ensure information exchange, capacity building, harmonisation of methodologies, international/ transnational synchronisation and coordination of activities

Description • Almost all fish species migrate on a regular basis, yet fish do not choose to be migratory. That is a fundamental and intrinsic trait of fishes on the species, population and individual levels. This is obvious for explicit migratory species such as sturgeons and shad, whose life-cycles extend over hundreds or even thousands of kilometres and varying ecosystems in the sea, estuaries and rivers. Nonetheless, migration is also important on the level of populations and even individuals of semi- and supposedly non-migratory species.

Migration barriers obstruct these movements and migrations of species, populations and individuals. They prohibit the completion of the life-cycle for mandatory reproductive migrants (e.g. sturgeons, shad), but also migrations by all species for e.g. dispersal, feeding, repopulation as well as balancing biomass and genetic exchange between different parts of the system in general. The dispersal aspect of ALL fish species is especially important because small, isolated populations have a lower resilience and therefore higher extinction risk. While migratory fish are generally good swimmers, many of the “non-migratory” species have very limited swimming capabilities, but still depend on dispersal to maintain genetic diversity and stable meta-populations.

Any man-made structure (barriers, intakes, groins, dykes etc.) in the aquatic environment can potentially impact fish migration. Some examples for migration barriers are hydropower dams, perched culverts and passages, emerged and submerged sills as well as weirs and sedimentation zones with reduced oxygen contents or steep temperature gradients on the longitudinal axis of the river (PAN-EU AP, 2018). River embankments, flood protection dams, and the disconnection of lateral sidearms and the floodplain – in many cases interconnected with hydropower dams – also hamper migration on a lateral axis.

In identifying barriers, this calls for considering that these may often be physical such as dams and weirs, but can also be biological/ecological, physical and chemical. Examples include thermal barriers, water level fluctuations, areas of unnaturally high predation/mortality, and hostile conditions for rheophilic species in impoundments.

Several decades of establishing and monitoring fish migration aids have yielded guidelines for upstream migration solutions that can be used for many fish species (e.g. Schmutz & Mielach 2013). Each barrier, however, has to be assessed in terms of impacts, purpose and ecological settings to define the optimal migration solution. And knowledge is limited for some species. Especially for sturgeons, no off-the-shelf specifications or "one-size-fits-all" passing solutions are typically available. This might also apply for the Danube Salmon.

This makes it mandatory to conduct at least a basic feasibility study for each migration barrier. Such studies must describe and analyse the current state and enable the development of a predictive balance of different passing solutions for the safe up- and downstream passage of all aquatic species and life stages. This includes quantifying important aspects of the targeted system for decision-making.

Such aspects comprise individual and cumulative impacts of the barrier on general ecological parameters such as hydrological and temperature regime as well as sediment transport. This also calls for addressing specific impacts on the presence of fish species and populations up- and downstream of the barrier and on aquatic habitat and habitat use, fish behaviour up- and downstream of the dam and main routes of approach. The location of entrances and alternatives in the technical layout of passage ways must also be considered (e.g. by telemetry and/or hydroacoustics). Additional mitigation measures, such as habitat restoration in the vicinity of the obstacle or the construction of additional new habitat (e.g. artificial spawning grounds) should also be included. Finally, additional impacts on the system like climate change and future infrastructural development and use should be considered. The key for the function of any passing solution is the amount of water and space that is made available (PAN-EU AP, 2018). Accordingly, options related to removing or adjusting barriers that prevent the passage of migrating fish and improving the flow of water and sediments must be assessed.

Milestones to assess ToM-implementation

1.1. Pre-feasibility studies for fish migration are included in all future barrier construction projects

1.2. The effect of physical and other barriers on the ecological corridor have been assessed

1.3. Prioritisation methods on the national and international scale are available to identify the need for action as determined by the natural distribution and movements of the target species of endangered migratory fish.

1.4. Options for barrier and dam removal have been assessed as a first choice to re-establish physical and ecological continuity

1.5. Passing solutions have been developed and implemented at barriers as a second choice, functioning at all times, for all species, sizes and developmental stages of the target species as well as functioning up- and downstream.

1.6. A common database on barriers and their passing solutions has been created, implemented and is maintained with open access for all involved stakeholders

1.7. Methodologies for assessment, implementation and function control of barrier/dam removal and establishing passing solutions have been standardised and harmonised.

1.8. Water abstraction and impoundment permits have been reviewed to implement the ecological flow in order to achieve good ecological status or potential of all surface waters and good status of all groundwater by 2027 at the latest, as required by the Water Framework Directive

Figure 6: At the hydropower plant Ottensheim-Wilhering in Austria, the Austrian hydropower company VERBUND built in recent years a more than 14-km-long bypass system with the support of a LIFE+ project. The bypass system fulfils the requirements of fish migration and also serves as a habitat. Such solutions are a first choice among migration facilities but they require sufficient place along a river section. When no place is available, e.g. in gorge sections, technical facilities might be an option (Photo: VERBUND 2020).

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) - Objective 4: Sturgeon migration (up-and downstream) is secured or facilitated.

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish.

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region.

DRBMP-update 2021, Joint Program of Measures, Interruptions of River Continuity

ToM 2 Protect and restore habitats of migratory fish

Target • Ensure habitat availability, accessibility and ecological continuity. Habitat conditions in the Danube ecological corridor ensure that all types of habitats spawning, nursery, feeding, wintering, etc.) of migratory fish exist to a sufficient extent, i.e. they support viable populations. With respect to ToM 1, open migration routes must ensure accessibility to and between these habitats.

Rationale • Habitat restoration is indispensable to improve the ecological corridor and ensure migratory fish conservation. MEASURES has developed and tested approaches to identify and verify different types of habitats for migratory fish. In the countries represented in the project, a core set of potential and actual sturgeon habitats was recorded. These form the basis for habitat protection and restoration and help to guide the remediation of migration obstacles. Further efforts are considered necessary to identify key habitats of migratory fish for protection and restoration efforts.

Principal addressees • Competent authorities, institutions, initiatives and networks in water management, nature and biodiversity protection at international (e.g. European Commission, EU-SDR – PA 6, Berne Convention), basin-wide (ICPDR) and national levels;

National and international priorities

- Protect sturgeon habitats already identified by MEASURE as critical with the set of legislation in place at the national as well at the international level (e.g. Nature 2000 areas/HD)
- Ensure habitat protection and when necessary restoration for key migratory fish species such as Nase, Barbel and Danube Salmon, especially in Natura2000 areas (e.g. Mura River)
- Fill knowledge gaps on habitats of all migratory fish (ToM 5) and protect these habitats, especially for threatened species
- In order to support the implementation of these priorities
- EU and EU-SDR are called upon to ensure protection of migratory fish against potential impacts of new policies and projects, and to strengthen cooperation across different sectors (water, nature conservation, hydropower, navigation, fishery…) and between the Danube and Black Sea
- Put in place management plans considering the needs of migratory fish for these habitats and ensure necessary adjustments of legal instruments (e.g. updating Annex II of the Habitats directive (species list) according to new data available, especially with regard to the sturgeon species

- Allocate appropriate resources to continue identification of habitats of key importance for migratory fish and to monitor progress;

- Ensure better legal solutions to protect key habitats and integrate the concept of the ecological corridor as an integral unit of connectivity, habitats and populations in the sectorial policies and environmental legislation

Description • Aquatic habitat protection and restoration are important measures at specific locations and are worth significant investments in order to preserve or return them for use by migratory fish species. These efforts include specific interventions to improve water quality or the natural patterns of flow necessary for ecosystem health; most importantly, physical restoration of freshwater habitats (barrier removal, bank stabilisation, re-establishment of channel morphology in a stream, wetland restoration etc); and also more traditional conservation tactics where land (or water) is placed under a "protected" status. The challenge with these Types of Measures is pursuing them at a scale of significance.

Sometimes restoration to an original state is not possible and all that can be achieved is some level of mitigation (i.e. remediation or rehabilitation in the above sense). Provided this restores at least some ecosystem services and reverses biodiversity loss, then such remediation or rehabilitation can be viewed as a positive intervention (Geist & Hawkins 2016).

Habitat protection and restoration should be considered together. To achieve a functional ecological corridor for migratory fish and based on economic considerations, existing natural habitat preservation should be given first priority, followed by key habitat restoration.

Milestones to assess ToM-implementation

2.1. Habitats to be protected and restored have been identified

2.2. A basin-wide harmonised methodology for prioritising protection and restoration measures has been developed

2.3. Feasibility studies have been performed and solutions identified according to selected species requirements

2.4. All necessary permits for restoration have been obtained

2.5. Solutions for habitat restoration are being implemented

2.6. Effects of restoration measures are being monitored and measures adapted, if necessary

2.7. A common database on protected / restored habitat has been created, is regularly updated and maintained

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) - Objective 3: Sturgeon habitats are protected and restored in key rivers.

EU-SDR-Action Plan – PA 4 – Water quality: Action 1: Hazardous & emerging substances, Action 2: Waste water, Action 3: Water & agriculture, Action 5: Migratory fish, Action 6: Climate change.

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region.

DRBMP-update 2021, Joint Program of Measures, Morphological Alterations

ToM 3 Develop, promote and implement green infrastructure for flood management and nature-based solutions for navigation

Target • Ensure the protection and enhancement of nature and natural processes. Negative ecological effects of future navigation and flood protection projects on national and international levels are already taken into account in the planning phases and are minimised to the extent possible.

Rationale • Green infrastructure promotes using non-structural methods to ensure e.g. flood management and navigation and promotes using the integration of natural and nature-based methods. MEASURES did not deal specifically with the negative effects of future navigation and flood management. Nonetheless, an analysis of existing infrastructure projects has not only shown their negative ecological effects but also that ecological requirements are not sufficiently addressed in the different planning steps.

Principal addressees • Competent authorities and institutions in water management, flood protection, navigation

National and international priorities

- Establish close cooperation and ensure involvement of migratory fish scientists in future navigation and flood protection projects at the early planning phase
- Adjust technical solutions for implemented navigation projects that impact proper conditions for eCOR and did not yield substantial benefits for navigation
- Ensure compliance of projects with the Espoo Convention (Convention on Environmental Impact Assessment in a Transboundary Context) in order to assess the environmental impact of certain activities that are likely to have a significant adverse environmental impact across boundaries (navigation, sand mining, dredging).
- Perform EIA in accordance to the national and European legislation and ensure an investor-independent EIA assessment

Description • Green infrastructure development means using non-structural methods to ensure flood management. This includes land use zoning as a first step, followed by integrating natural and nature-based methods, combined with hard engineering if needed, to manage flood risk. Natural and nature-based methods such as opening floodplains, upstream reforestation, green roofs on downstream urban areas, and wetland restorations and management can improve the function of – and reduce the overall costs associated with – conventional engineering. They also allow communities to reap the co-benefits the environment can provide such as: cleaner wa-

ter, reduced air temperatures and green space for human recreation while protecting livelihoods such as agriculture and fishing.

In the case of navigation, promoting green infrastructure/nature-based solutions should be the basis of all discussions. Solutions for a better waterway could involve a combination of limited hard hydrostructural works with wise sediment management, artificial islands, natural bank-reinforcement, etc.

Of the eleven infrastructure projects that were reported during plans and policy paper analyses performed in MEASURES – either ongoing or planned along the Danube River – the majority is dedicated to assessing, adjusting/harmonising and improving the conditions for navigation. This is because navigation is seen as an environmentally friendly type of transport with low carbon emission. In comparison, only few projects relate to hydropower production or to flood risk mitigation and water supply.

Milestones to assess ToM-implementation

3.1. Flood risk areas and river sections having high priority for navigation ("bottlenecks") have been identified

3.2. Close cooperation with and involvement of migratory fish scientists already at an early stage in future flood risk and navigation projects has been established

3.3. Areas of intervention have been prioritised

3.4. Habitat and species that will be impacted have been identified

3.5. A common database of projects has been created and is regularly updated and maintained

3.6. Feasibility studies have been performed to identify solutions in accordance with habitat and species requirements, also preserving environmental services

3.7. All necessary permits have been obtained and public consultations performed

3.8. Technical solutions have been implemented

3.9. Effects of measures are being monitored and measures adapted, if necessary

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) - Objective 3: Sturgeon habitats are protected and restored in key rivers, and Objective 4: Sturgeon migration (up-and downstream) is secured or facilitated.

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish.

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 5: Anchoring the concept of EU green infrastructure in the Danube Region.

DRBMP-update 2021, Joint Program of Measures, Future Infrastructure Projects

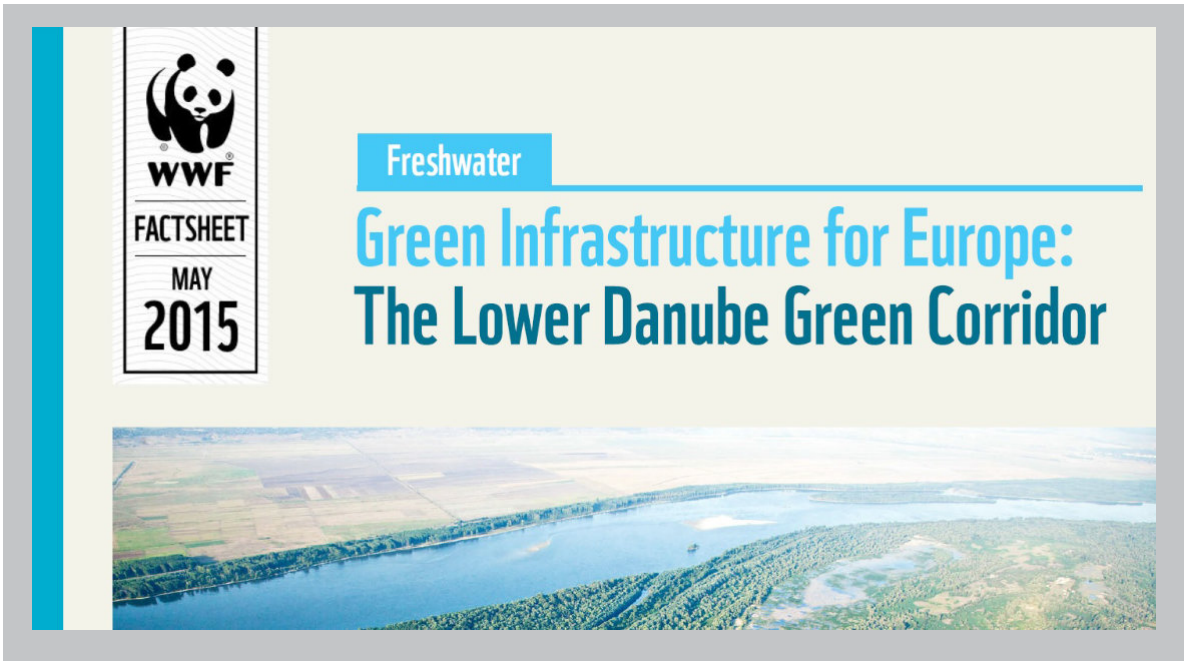


Figure 7: Several available documents promote the need for green infrastructure in general and on the Danube more specifically.

ToM 4 Secure and support populations of sturgeon species and other migratory fish by ex-situ measures

Target • Save populations from extinction. To support threatened and re-establish extinct fish populations by ex-situ measures until wild fish populations are sufficiently recovered. Currently, this applies especially to the native Danube sturgeon species.

Rationale • Endangered populations need protection in the wild, but sometimes also supportive ex-situ measures to rebuild population structure by releasing genetically suitable individuals from controlled propagation.

International classifications of the conservation status list, among the five Danube sturgeon species, one as extinct (*A. nudiventris*), one as functionally extinct (*A. gueldenstaedtii*), two as critically endangered (*A. stellatus*, *Huso huso*) and one as endangered (*A. ruthenus*). Without living gene banks in ex-situ facilities, population recovery not possible. The only option to safeguard viable native populations of these species is ex-situ measures, undertaken until populations reach a viable level, migration routes are open and sufficient habitats are available.

Principal addressees • Competent authorities and institutions in nature and biodiversity conservation; research institutions to ensure state-of-the-art implementation

National and international priorities

- Build state-of-the-art ex-situ facilities for Sterlet conservation stocking in Austria and Slovenia
- Build state-of-the-art ex-situ facilities for anadromous sturgeon species (*A. stellatus*, *A. gueldenstaedtii*, *Huso huso*) conservation stocking in Bulgaria, Romania and Serbia
- Establish twinning facilities for risk spreading
- Exchange animals (spawners, juveniles) as "genetic exchange"
- Identify the need for activities for Danube Salmon, esp. in the middle Danube and several tributaries such as the Mura River

In order to support the implementation of these priorities

- Ensure the necessary funds
- Ensure information exchange, capacity building and harmonisation of methodologies

- Ensure international/ transnational synchronisation and coordination of activities

Description • A population status below a certain threshold will not allow for recovery on its own and inevitably lead to extinction. Such populations need protection in the wild, but also supportive programmes for rebuilding population structure by releasing genetically suitable individuals that are fit for survival under natural conditions and stem from controlled propagation in specialised facilities. This is commonly known as ex-situ measures or conservation aquaculture.

Many fish species are threatened by habitat degradation and over-exploitation. Attempts have often been made to compensate population deficits and/ or associated fishery takes by rearing fish in hatcheries and releasing them into the wild, commonly known as "stocking". Such releases have been reviewed critically in recent years because many of these activities did not yield the desired success or even had negative effects on populations. Certain fish and especially sturgeon populations, in contrast, would have been lost without human intervention and appropriate conservation measures, also involving the reproduction of broodstock in captivity.

The successful use of controlled propagation for the conservation of fish strongly depends on how well hatchery-reared animals can adapt to natural habitat conditions. An important issue is how well hatchery operations can preserve the genetic identity and diversity as well as all other key attributes of the natural populations.

Ex-situ measures consist of establishing broodstock from endangered populations in captivity and their reproduction under (near-)natural environmental conditions. The goal is to release juveniles that are fit for survival in the wild. They therefore work in accordance with the life-cycle of the populations, ensuring the feasibility of measures with regard to a functioning aquatic ecology and ecosystem health.

Such measures are intended to "buy time" to ensure the successful implementation of in-situ improvements like habitat protection and restoration. Nonetheless, such recurrent introductions of individuals from a captive environment into natural populations harbours the threat of altering the gene pool and detrimentally affecting the population. Accordingly, one of the most important aims of ex-situ measures is to maintain and protect the genetic identity and diversity, as well as the morphological and behavioural characteristics, of the respective populations in both captivity and the wild.

This clearly distinguishes ex-situ programmes from introductions in areas without native populations, from economically boosting a fishery by releasing juveniles, as well as from commercial hatchery operations that produce fish and fish products for human consumption.

The different terms used for ex-situ operations include "conservation stocking", "conservation breeding", "conservation hatchery", "conservation aquaculture", "captive breeding" or simply "hatchery". The latter is often misleading because ex-situ measures go beyond the concept of merely producing large quantities of fertilised eggs and letting them hatch. Nonetheless, these terms basically have the same meaning if used in the context of sustainable conservation measures for endangered fish populations.

The life-cycle of the respective populations in the wild defines the conditions of ex-situ

operations and the underlying principles for the conservation of migratory fish in general. This means that ex-situ measures are also closely linked to other conservation activities such as habitat protection and restoration, as well as restoring continuity at migration barriers. As such, these measures have to be well coordinated and synchronised.

Figure 8 demonstrates the main differences between ex-situ operations and aquaculture for human consumption using the example of sturgeons. The only common feature of these two different approaches is adult sturgeon broodstock being reproduced in a captive environment. Note, however, that broodstock and captive environments differ greatly. Experience from other watersheds and populations has also shown that these two concepts cannot be consolidated for the aim of conservation of endangered populations.

Milestones to assess ToM-implementation

4.1. Relevant species and populations of migratory fish in need of ex-situ measures/programmes to prevent extinction have been identified (addressing all migratory species other than the extinct/critically endangered sturgeons, which are clearly in need)

4.2. Ex-situ facilities and procedures for conducting ex-situ programmes have been established

4.3. Genetically suitable broodstock has been established, secured and is maintained under conditions that minimise negative impacts on wild populations (e.g. collection and raising of juveniles and captive individuals)

4.4. A common database on broodstock and ex-situ operations and programmes for all stakeholders involved has been established, is regularly updated and maintained

4.5. Ex-situ operations are being conducted and juveniles released for rebuilding populations in the wild

4.6. Ex-situ operations are monitored and adjusted regularly to adapt to changes and to accommodate progress in knowledge and expertise

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) - Objective 2: Sturgeon population structure is actively supported to reverse the decline.

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish.

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region

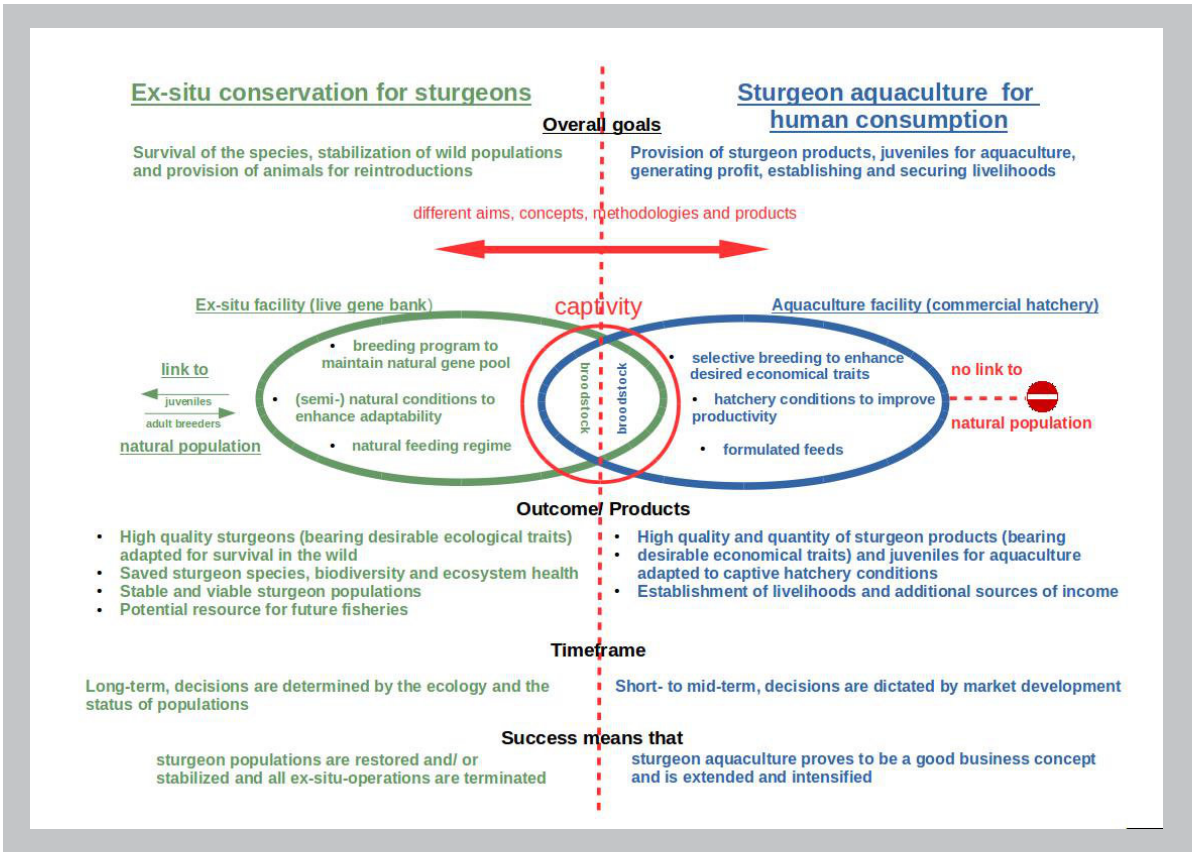


Figure 8: Differences between ex-situ measures and commercial aquaculture based on sturgeons as an example (from Reinartz 2015).

Figure 9: Handling of a large sturgeon spawner in an ex-situ facility (Photo: Ralf Reinartz).

ToM 5 Monitor connectivity, habitats and migratory fish populations

Target • Ensure knowledge-based management of populations and habitat. Regular monitoring is secured via integration into the relevant management and policy plans. An important aspect is to secure the necessary funds to fill remaining knowledge gaps, especially for potamodromous migratory fish habitats and populations, and to accompany and control the effects of the above-mentioned ToMs. Monitoring of migratory fish provides evidence whether ecological corridors function and whether fish migration aids function.

Rationale • Research and monitoring of populations and habitat is the basic prerequisite for any kind of population and habitat management. MEASURES has delivered new knowledge on potential and actual sturgeon habitats, but the involved fish ecology experts have underlined still existing knowledge gaps.

Principal addressees • Competent national and international authorities and institutions in water management, nature and biodiversity conservation, fishery, research

National and international priorities

- Include monitoring of migratory fish into the scope of ICPDR's Transnational monitoring and devote a separate section of the "TMNM Yearbook" to migratory fish
- Ensure that fish migration aids at key bottlenecks for the entire Danube Basin (e.g. Iron Gates, Gabčikovo) as well as at the regional level are subject to regular or even continuous function controls. This is necessary to demonstrate that fish migration aids work properly and that ecological corridors and measures taken (such as supporting stocking efforts) deliver what they promise. This approach also provides first indications that populations of migratory fish are in place.
- Monitor habitats and populations of anadromous sturgeon in the lower Danube and Black Sea
- Monitor habitats and populations of sterlet and in the upper and middle Danube and its tributaries
- Prepare pilot activities to e.g. assess potential habitats for reintroduction of migratory species in Hungary and Slovakia after restoring river continuity at the Iron Gate
- Develop and implement a migratory fish monitoring methodology in all DRB countries as part of the existing Joint Danube Survey

In order to support the implementation of these priorities

- Mandate a working group to design a Danube-wide network of monitoring sites and a monitoring programme tailored to migratory fish (building on monitoring of fish already in place to meet requirements of EU Water Framework Directive and nature legislation)
- Ensure the necessary funds
- Ensure information exchange and awareness raising, capacity building, harmonisation of methodologies
- Ensure international/ transnational synchronisation and coordination of activities

Description • Fish populations need habitat: the inherent habitat use by populations ensures the completion of the life-cycle and survival of the species. This makes the monitoring of populations, important life stages and their habitat crucial for delivering important information on the state of populations, habitat use and life-cycle-habitat. This is the basic prerequisite for any kind of intervention and management, i.e. the development and implementation of conservation measures. It creates the up-to-date population and habitat knowledge necessary for decision-making.

The management and conservation of fish populations and their habitat requires detailed knowledge on the population status and its habitat resources. Equally important are the detection of changes within this system, the identification of the underlying causes and impacts, as well as the power to conduct remediation actions if and whenever necessary.

Population and habitat assessments lay the foundation for population monitoring. In contrast to single or recurring assessments, however, monitoring is designed as a systematic continuous or repeated observation, measurement and evaluation of fish populations and habitat parameters or indices, according to predefined goals. This means that a monitoring programme must possess strong analytical or diagnostic power to 1) enable early warning of changes within the monitored system, calling for early control of the effectiveness of measures, activities and remedial actions, and to 2)prevent possible future damage.

For migratory fish populations and their habitat, often encompassing international waters and crossing borders, such activities have to be planned mutually, synchronised and then implemented by all range countries using a jointly adopted methodology.

A **monitoring programme** is specific for each population, follows the scientific state-of-the art as well legal standards required by e.g. conservation policy, and consists of several main components that need to be developed. The general **monitoring objectives** are to assess the current state and to detect changes in the monitored system. Further objectives concern the desired precision, confidence, spatial resolution, time scale and identification of causes of detected changes. Details are provided in Figure 10.

Milestones to assess ToM-implementation

5.1. Relevant species, populations and habitat needs have been identified based on conservation status and distribution to define target species and habitat for all further measures

5.2. Habitat has been identified and described as both location and timing of habitat use, as well as the necessary physico-chemical and ecological conditions and resources

5.3. A common database on populations and habitat has been established, is updated and maintained regularly, open for all stakeholders involved

5.4. Monitoring procedures and programmes for populations and habitat have been developed

5.5. Populations are monitored in subsequent assessments of important developmental stages during the life cycle, and population changes and trends are being documented

5.6. Habitat and its functionality in supporting habitat use is being monitored

5.7. Monitoring methodologies have been standardised and harmonised within the distribution area of the species

5.8. Measures for population and habitat protection and restoration are carried out based on all of the above

Figure 10: Scheme of a comprehensive monitoring programme.

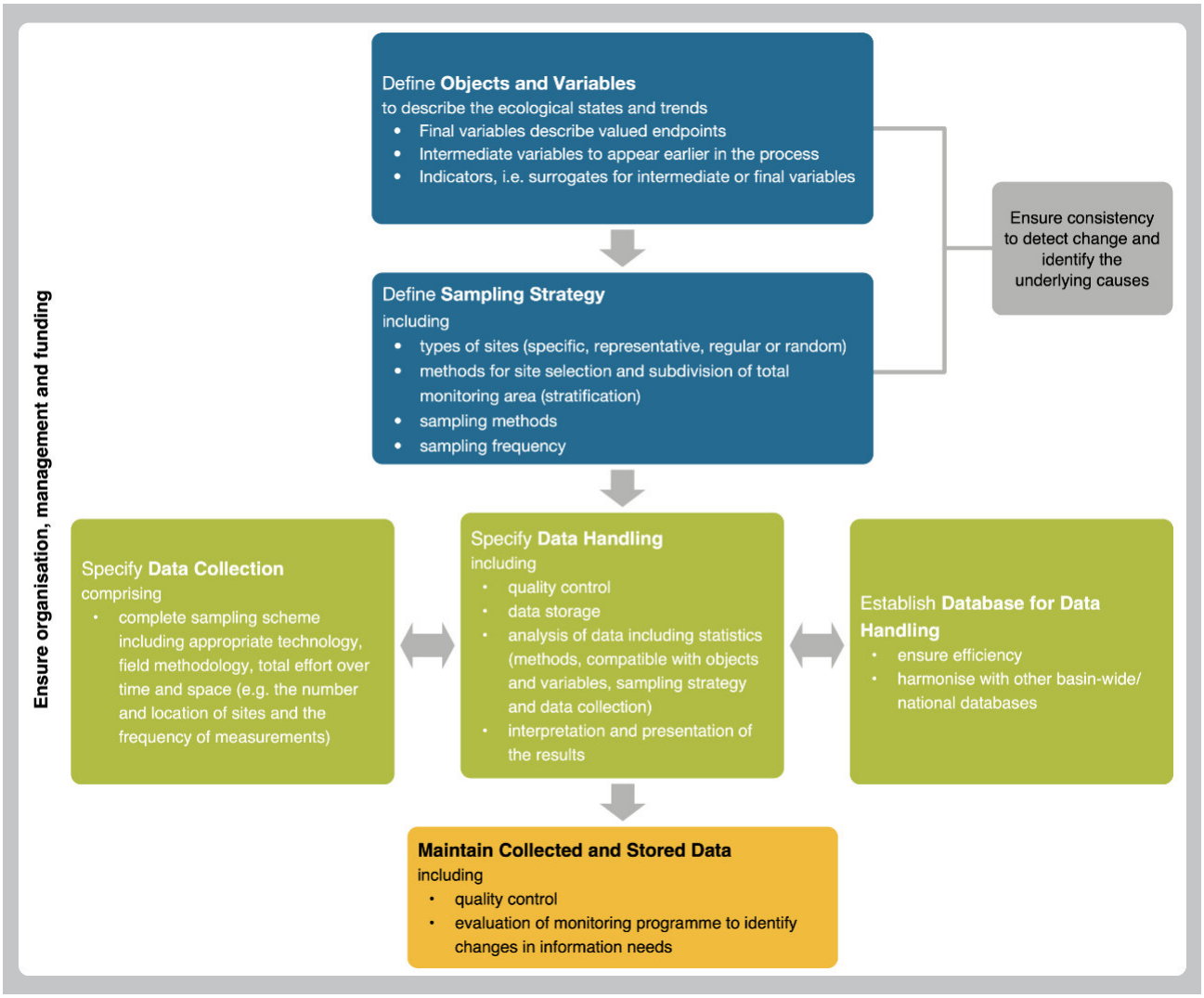


Figure 11: The ecological corridor of the Danube in Vienna. Braided blue structures indicate historical pattern of temporal river stretches and furcations, creating a dense and diverse pattern of river flow and habitat for a multitude of fish species (from Hohensinner 2020).

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) - Objective 5: Timely and continuous detection of population sizes and changes in remaining wild stocks

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region

ToM 6 Elaborate comprehensive National Activity Plans for Migratory Fish Species

Target • Ensure applicability of the Strategy also on the national level. Developing a comprehensive set of activities, going beyond the technical foci of the MEASURES project.

Rationale • National Activity Plans for Migratory Fish Species (NAP-MFS) ensure consistent targets, activities and implementation on the national scale. They allow accounting for local and regional specifics as well as for international and basin-wide targets and framework conditions.

NAP-MFS should be built based on the MEASURES Strategy. In MEASURES partner countries, local networks can initiate the NAP-MFS. MEASURES has focused on habitat identification, genetic analysis of sturgeons and ex-situ propagation of sturgeons, national network building, and analyses of management and policy plans. Many topics were not addressed, but it should be ensured that they are dealt with and integrated into consistent and comprehensive plans in the future.

Principal addressees • Competent authorities and institutions in water management, nature and biodiversity conservation, fishery, agriculture and other stakeholders according to stakeholder analyses on the national level.

National and international priorities

- Screen ToMs of this Strategy and the national activities as mentioned in the annex and identify further priorities not addressed in MEASURES
- Establish opportunities for regular transnational exchange on development and status of NAP-MFS, necessary updates, etc.
- Seek synergies with existing Action Plans and solve conflicts with other projects, initiatives and policies

Description • Restoring the ecological corridor as well as protecting and enhancing migratory fish populations is a complex task. Beside gaps in ecological knowledge of fish populations and habitats, it requires defining ecological targets, developing measures to reach those targets and implementing those measures. In addition, nature conservation and restoration efforts must account for the framework conditions in which ecological decisions and activities are embedded. For migratory fish of the Danube and its tributaries, multilateral exchange and harmonisation are necessary. Those stakeholder needs whose targets oppose the ecological ones must be dealt with and (best) compromise solutions must be found in which ecological impacts are minimised.

In order to ensure that the complexity of migratory fish conservation is fully addressed, National Activity Plans for Migratory Fish Species (NAP-MFS) should be developed.

NAP-MFS ensure consistent targets, activities and implementation on the national scale. They help account for local and regional specifics as well as for international and basin-wide targets and framework conditions.

NAP-MFS shall be developed based on all available data on the migratory fish species and populations in question. Action Plans for biodiversity conservation typically include inventories of biological information for selected species or habitats, an assessment of the conservation status of species within specified ecosystems, targets for conservation and restoration, as well as budgets, timelines and institutional partnerships for implementation. Groves et al. (2002) have suggested a seven-step programme for Conservation Action Planning, which can be also be considered as an exemplary approach for migratory fish species: (1) identify conservation targets, (2) collect information and identify information gaps, (3) establish conservation goals, (4) assess existing conservation areas, (5) evaluate the ability of conservation targets to persist, (6) assemble a portfolio of conservation areas and (7) identify priority conservation areas.

The NAP-MFS based on this MEASURES Strategy document shall subsequently describe the targets with respect to migratory fish, the main measures and activities necessary to reach these targets, as well as the programme to monitor the effects of activities as well as to monitor the development of fish species and populations along with indicators of success. Important components include a clear time-schedule as well as a list of stakeholders who were involved in defining targets and measures and/or who are concerned with implementing the measures. In MEASURES partner countries, local networks can initiate the NAP-MFS (see Type of Measure 7).

Milestones to assess ToM-implementation

6.1. The preparation of national activity plans has been initiated

6.2. Support and necessary funding for the preparation of activity plans has been obtained from national authorities or other sources (e.g. European funds)

6.3. A (legal) governance framework for the ecological corridor has been defined and support from national authorities has been obtained

6.4. Basin-wide targets specified in this Strategy have been adapted and detailed in accordance with national specifics and stakeholder priorities

6.5. The implementation, monitoring and success control of the NAP-MFS has been initiated

links to…

The Pan-European Action Plan for Sturgeons (PAN-EU AP) – all objectives.

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish, Action 7: Tools

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and / or implement conservation action plans and / or management plans for endangered umbrella species of the Danube Region

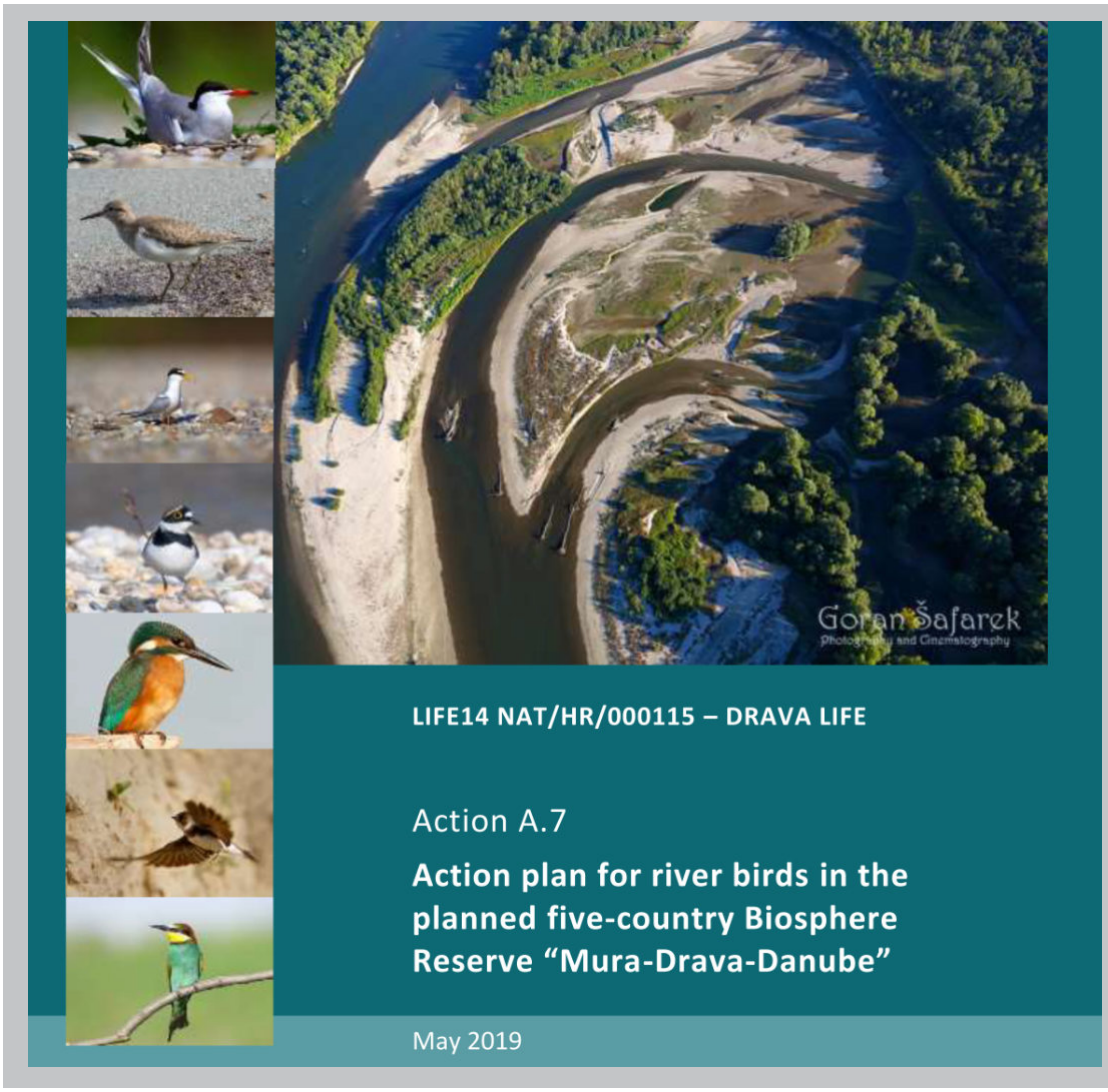


Figure 12: In 2019, an Action Plan for river birds in the planned five-country Biosphere reserve "Mura-Drava-Danube" was published. Such Action Plans can serve as a guide for developing national activity plans for the Danube ecological corridor and migratory fish, but they can also offer synergies for joint conservation targets.

ToM 7 Strengthen "Local Migratory Fish Networks"

Target • Create structures of expertise and responsibility. Further develop the MEASURES networks initiated on local and national levels as well as establish organisational structures for ecological corridor and migratory fish conservation on the national scale while simultaneously ensuring transnational exchange and harmonisation.

Rationale • Well-established Local Migratory Fish Networks ensure the implementation of the NAP-MFS (see Type of Measure below). They can act as exchange and cooperation platforms on a basin-wide or even European scale. They also allow a timely reaction if framework conditions change. Organisational structures to promote and ensure the conservation and restoration of the Danube ecological corridor are still missing. However, well-established organisational structures offer many advantages and should therefore be pursued. For example, they compile existing expert knowledge and make this easily available to individual network members, they offer fast communication and short reaction times, or they help increase awareness.

Principal addressees • Competent authorities and institutions on the international and national level as well as NGOs, associations, research institutions and the private sector in water management, flood protection, nature and biodiversity conservation, research, fishery, navigation, hydropower

National and international priorities

- Identify responsible bodies and demand commitment from them to support implementing measures and activities of this Strategy by including relevant aspects into management and policy plans (e.g. National River Management Plans)
- Further elaborate the tasks of the LMFNs and the contents of the NAP-MSF
- Identify and designate the relevant national actors/stakeholders/structures (if present) and assign specific tasks to as well as demand commitment from them
- Identify relevant existing local and national networks to explore synergies and options for cooperation
- Ensure exchange of Local Migratory Fish Networks on a basin-wide scale
- Enhance coordination with authorities competent for other sectors at national and international level
- Enhance cooperation between the Danube Region and Black Sea Region, focusing on all issues of relevance for migratory fish

- Identify and verify issues of transnational concern
- Identify funding sources and ensure funding
- A basis for Local Migratory Fish Networks has been established in most MEASURES partner countries. In case new LMFNs should be established, a mapping of stakeholders should be the starting point.

Description • Local Migratory Fish Network (LMFN) in the context of this Strategy relates to a fixed group of stakeholders. They will communicate and meet on a regular basis to implement one or several specific measures and activities with regard to the ecological corridor for migratory fishes. The Strategy and the Types of Measures can serve as a framework. LMFNs are responsible for developing the National Activity Plans for Migratory Fish Species (NAP-MFS, see Type of Measure 2) and for initiating and controlling implementation. They can be formed by a core group of organisations and entities that are primarily involved in nature conservation and restoration. At the same time, they strive to inform a wider group of concerned stakeholders or to involve such groups in prioritising activities or decision making. It is recommended that LMFNs define rules and guidelines by which to function. Further, they delegate members to transnational and international networks or meetings and report and exchange there about local and national activities to improve the functioning of the ecological corridor. Migratory Fish Networks allow a timely reaction if framework conditions change, provided NAP-MFS have clear and traceable descriptions on how to observe such framework conditions.

In the constitutive phase, systematic mapping of stakeholders by initiator(s) is recommended. This is designed to ensure the consideration of all relevant legal and administrative institutions, important associations, networks and actors who are concerned with biodiversity and conservation as well as with the restoration of the Danube ecological corridor, especially with the respective needs of migratory fish and their habitats. Parallel to stakeholder mapping, an investigation of relevant ongoing processes and framework conditions (legal framework, administrative responsibilities) is recommended. Mapping of existing associations and networks will also allow connecting LMFN to existing structures to reduce the additional workload to the extent possible.

Apart from activities on the national and regional scale, Local Migratory Species Networks act as exchange and cooperation platforms on a basin-wide or even European scale. Links to existing organisations as well as local, national and basin-wide networks concerned with biodiversity and nature conservation and river restoration should be established. On the transnational scale, the DSTF, the EU-SDR (in particular PA6) and the ICPDR are of particular interest to facilitate basin-wide exchange as well as to consider closely related targets.

Milestones to assess ToM-implementation

7.1. Local Migratory Fish Networks (LMFNs) have been initiated or existing ones stabilised

7.2. Targets and tasks of local networks (including training and capacity building for relevant stakeholders) have been defined

7.3. Scientific, institutional and financial support has been secured

7.4. Gaps and weaknesses in the legal and institutional framework have been accounted for

7.5. Exchange on the basin-wide scale among LMFNs (e.g. annual meetings) as well as with relevant organisations such as ICPDR, DSTF and EU-SDR (in particular PA 6) is established and ensured

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) – all objectives.

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish, Action 7: Tools

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 2: Build capacities of national and local authorities, non-governmental organisations, expert and scientific community in environment-related matters, Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region

ToM 8 Improve public participation and support for Local Migratory Fish Networks

Target • Ensure public, stakeholder and political support. To create the framework for public debate for decisions and projects in order to raise their acceptance in society

Rationale • Public participation is a process that directly engages the public in decision-making and gives full consideration to public input in making such decisions. The more complex the subject of debate is, the greater the variety of interests that will emerge from different organisations: research institutes, universities, NGOs, governmental authorities, local authorities etc. Communication and facilitation skills then become key elements to build relationships and obtain appropriate data and information to develop realistic plans and projects. The MEASURES project developed an External communication strategy that can be adapted and improved according to different needs because the communication strategy does not cover all aspects of the eCOR conservation

Principal addressees • Competent authorities and institutions involved in water management, nature conservation and fisheries management on the basin and national level, NGOs, organisations and associations, projects beneficiaries

National and international priorities

- Build water democracy by establishing local water councils
- Better involve stakeholders and public in decisions regarding river management planning, especially on national levels; the ICPDR Public consultation processes can serve as examples
- Build capacity among all levels of stakeholders, including raising awareness of the general public, regarding the requirements and management options for fish conservation (Slovenia)
- Initiate harmonisation of multi-national plans for shared river catchments
- Initiate harmonisation of fishing and the legislation of other sectors with cross border influence

Description • The Aarhus Convention and its Protocol on PRTRs empower people with the rights to access information, participate in decision-making in environmental matters and to seek justice. Public participation seeks and facilitates the involvement of those potentially affected by or interested in a decision. It is a process – not a single event – and should be planned from the early stages of management plans or project development. At the same time, the challenge of ensuring an adequate and equitable treatment of participants in consultation processes should not be underestim-

ated. The more complex the subject of debate is, the greater the variety of interests that will emerge from the different organisations: research institutes, universities, NGOs, governmental authorities, local authorities, fishers, etc. This means that communication and facilitation skills become key elements to build relationships and obtain appropriate data and information to develop realistic plans and projects.

Public participation is not simply a nice or ancillary thing to do: it actually results in better outcomes and better governance. When done appropriately, public participation will yield two significant benefits:

- Decision makers and project beneficiaries will make better and more easily implementable decisions that reflect public interests and values and are better understood by the public.
- Communities develop a long-term capacity to solve and manage challenging social issues, often overcoming longstanding differences and misunderstandings.

The eight local networks for migratory fish conservation from the Danube countries involved in the MEASURES project have been identified by using a complex matrix. That matrix takes into consideration general information, the spatial scale of their impact, category, area of interest, what we want from them, past cooperation, contribution to the project including conflicting interests, as well as contact persons and their responsibility in the institution. The networks have a complex structure, wide representation and potential members have been involved in the Strategy development during three rounds of national workshops and the final conference.

Milestones to assess ToM-implementation

8.1. Social and political scientists are involved in LMFNs, especially experts in governance as well as experts in fostering stakeholder and policy dialogue

8.2. A stakeholder analysis has been performed

8.3. A communication and involvement strategy which accounts for different types of stakeholders as well as for the general public has been developed. Input and feedback from and dialogue with these groups has been ensured

8.4. The period allocated for the consultation has been established

8.5. Stakeholder meetings and round tables focussing on interactive exchange between LMFNs and stakeholders are being organised and conducted

8.6. Results of meetings are being recorded and kept available for all involved stakeholders

8.7. Public consultation is being capitalised on. Decision makers are informed about the results of consultations. As a first step, concrete measures identified within the MEASURES project have been submitted to ICPDR and its consulting parties

8.8. Stakeholder input in public consultation processes is recognised and the consultation process results are being communicated to the general public

8.9. Citizen Science and other awareness-raising activities among the general public are being promoted

8.10. Guidance documents for municipalities and other target groups on the available green solutions, NBS and ecosystem-based management are being developed and disseminated

links to...

The Pan-European Action Plan for Sturgeons (PAN-EU AP) – Objective 8: Sturgeons serve as flagship species for healthy river ecosystems. Support from the public, political actors, authorities and relevant stakeholders for conservation measures has increased

EU-SDR-Action Plan – PA 4 – Water quality: Action 5: Migratory fish

EU-SDR-Action Plan – PA 6 – Biodiversity and landscapes, quality of air and soils: Action 3: Develop and/or implement conservation action plans and/or management plans for endangered umbrella species of the Danube Region

06 Strategy implementation

The successful implementation of this Strategy depends on different competent authorities and institutions responsible for protecting, restoring and maintaining an ecological corridor. As no single authority or institution – neither on the basin nor on national levels – is responsible for all three elements of the ecological corridor, coordinated actions are needed.

Principal addressees are the relevant basin-wide (esp. ICPDR, coordinators and members of EU-SDR PA 6, etc.) and national authorities and institutions from the sectors of river basin management as well as biodiversity and nature protection. Water management institutions concerned with developing, updating and implementing the River Basin Management Plans must strive for physical river continuity and habitat conditions that allow achieving good ecological status or good ecological potential.

The competent authority for transboundary water management in the Danube Basin is the ICPDR. It has the powers necessary to mandate Danube states to take measures to establish such corridors, including both continuity measures and habitat measures.

Conservation of migratory fish is at the crossroads between water management and management of nature and biodiversity. While nature protection authorities and institutions take certain responsibilities for habitat protection and restoration, their role is often less prominent than water management institutions. This raises the need to clarify the roles and responsibilities of national nature and water management.

There are currently no legal obligations to sustain critically endangered fish populations by means of conservation hatcheries (i.e. ex-situ facilities). Given their nature

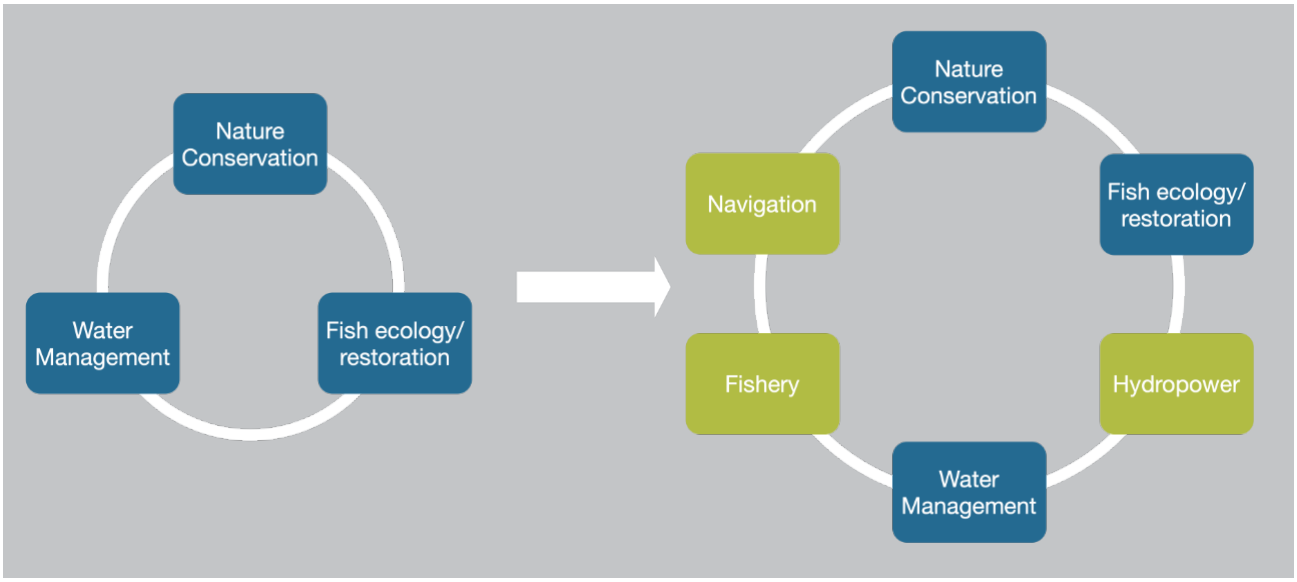


Figure 13: As a starting point, only few stakeholder groups might be involved in implementing the Strategy for ecological corridor conservation on the national but also on the basin-level. It is envisioned that, over time, all relevant stakeholder groups are involved (right side of figure).

and purpose, as well as the legal instruments they have, it is proposed that nature protection authorities in the EU and concerned Danube States should take responsibility to support, initiate or establish such ex-situ facilities.

There are sectors beyond the above-mentioned that exert significant adverse effects on continuity, habitats and fish populations. Such adverse effects will increase in the future, e.g. for navigation, hydropower or sand/gravel mining. There is a need to ensure that policies and their implementation effectively support the recovery and conservation of the Danube ecological corridor. The EU, the ICPDR and the EU-SDR (PA 06) should take the lead in developing this support (in particular for sectors with transboundary consequences such as energy, climate and inland waterway transport) with a view to implementation by the relevant competent national authorities.

The recommendation is to initiate and establish organisational structures for such cross-sectoral exchange on basin-wide and national levels. These can build on the Local Migratory Fish Networks initiated in the countries represented in the MEASURES project. There is no coherent situation in these countries due to national differences in challenges related to the ecological corridor and migratory fish, but also due to differences in already established communication between stakeholders from different sectors. Sometimes, the initial LMFNs comprise only a smaller group of stakeholders focussing on nature conservation and biodiversity; sometimes, more diverse stakeholder groups have already agreed to support and actively engage in implementing this Strategy.

As detailed in Chapter 5, ToM LMFN, further extending such networks towards an international level is urgently needed to ensure a basin-wide exchange, agreements, coordination and harmonisation of measures and activities.

6.1 Indicators and monitoring of success

Monitoring of the success is an important element of implementing this Strategy. It should be done on two levels, i.e. on the level of milestones as well as on the level of measures and activities as formulated in the NAP-MFS.

The following list of indicators follows the timeline as suggested for the ToMs, the milestones (see Chapter 2) and implementation steps. There are two types of indicators. Some are binary (yes or no), while others are quantitative and can be measured in numbers. Especially for qualitative indicators, further specification should be provided. For example, for the indicator "Relevant deficits in habitat, populations and continuity identified" a target area should be given. No timing is considered, but timeframes should be defined by the different LNMFs on the country level. We also recommend to define targets to be reached within this time period.

Depending on the more specific activities as defined e.g. in the NAP-MFS, additional indicators can be defined. Importantly, indicators must be clearly measurable. For those indicators that cannot be quantitatively measured or for which a binary evaluation is not possible, the recommendation is to add criteria which prove success.

Local Migratory Fish Networks can be responsible for monitoring the indicators of success.

Table 6: List of indicators to monitor the implementation of the measures and activities aiming at securing and restoring the ecological corridor and migratory fish.

Indicator	Type of measure-ment	Further specification
Relevant deficits in habitat, populations and continuity identified	Qual. (yes/no)	River or river section
Current (used) habitat, potential habitat (e.g. for reintroductions), habitat conditions/ resources and pressures identified and described	Qual. (yes/no)	River or river section
National and international relevance of measures and activities identified	Qual. (yes/no)	Not relevant
National Activity Plans completed, including conservation and restoration of populations, habitat and physical continuity	Qual. (yes/no)	Not relevant
No. of projects developed	Number	Define target number
Sufficient funding secured	Qual. (yes/no)	Define for which activities funding is needed
No. of projects implemented	Number	Define target number
No. of habitats for which formal protection status has been achieved	Number	Define target number
No. of restoration projects ongoing or completed	Number	Define target number
No. of monitoring programmes in place	Number	Define target number and specify which kind of monitoring (e.g. habitat, fish populations, migration), define river/river section
No. of physical continuity conserved and restored	Number	Define target number
No. of ex-situ programmes running	Number	Define target number and for which fish species
Population targets for monitoring and management defined	Qual. (yes/no)	Define e.g. minimum number for abundance or biomass
No. of policy and management plans into which Types of Measures specified in this Strategy were integrated	Number	Define target number
Overall number of activities implemented or applied in practice	Number	Define target number
Continuous length of ecological corridor resulting from Strategy application within policy and management	Number	Define target length

07 Challenges to take into consideration and risks of failure

Even the best-planned strategy can encounter unexpected problems. These can be related to human, operational, procedural, financial, technical, natural and political aspects that potentially affect meeting the targets and objectives of the Strategy. Not all risks are negative. Some events or conditions can be helpful and, when they occur, these turn into opportunities.

The present Strategy covers a wide territory as well as countries with different cultures and different accessibility to resources. Accordingly, 10 potential evaluations of different kinds of risks have been made at the national level in terms of the probability of occurrence. These have been grouped as high, medium and low risks. The overview below summarises these national evaluations on the basin scale.

The present document has no legal weight and depends heavily on promotion by the contributors to keep it alive and on the willingness of the responsible authorities to take up and implement the Strategy. As consequence, the highest risks are associated with human, financial and procedural categories such as **low or no interest of the stakeholders for the Strategy, changes of key persons among stakeholders including project partners, insufficient or no funds for measures implementation** and **important delays in the implementation schedule**. Establishing viable stakeholder networks requires sincere debates, an understanding of all points of view, trust and time. Some countries have been able to build on older relationships, but in many cases networks are merely at a very early phase. In the latter cases – given that the time to built such networks during the MEASURES project was short – the interest in the Strategy measures could not be sufficiently strengthened. In both cases, too many changes of involved people can

weaken the network. Preserving but especially restoring longitudinal river continuity often requires large-scale and expensive projects, which must go through complex procedures that can sometimes cause lengthy delays. Ensuring the necessary funds for measures implementation can became a challenge if they fail to be integrated in policy and management plans accompanied by proper funding programmes. In the coming years, however, the available funds will be greatly influenced by the evolution of the Covid-19 pandemic and the need for economic recovery. At the same time, they will also be linked to a more sustainable development, offering new funding opportunities for biodiversity.

Medium risk covers **limited or no access to new data, absence of a focal point in each country, high costs and lack of technical solutions to implement the Strategy measures, as well as weather, natural disasters or disease**. In some countries the data are shared by several owners or there is no culture of transparency; such cases pose a challenge to keep the MEASURES Information System MIS properly updated. Active focal points should coordinate the Strategy implementation at the national level and keep in touch with initiatives from other countries. Since no funds are available to hire such a designated person in each country, the focal point should assume this role voluntarily or that role should be assumed by responsible authorities.

Preserving but especially restoring longitudinal river continuity often requires large-scale engineering solutions that consume technology, human resources and funds. Many state-of-the-art technologies are available, and EU funds used on the basis of complementarity can reduce the risks of high costs and lack of technical solutions. When it comes to dams, however, solutions and money can became constraints.

Weather, natural disasters or disease are difficult to predict. Nonetheless, as climate change progresses, we can expect to increasingly face floods, droughts, major vegetation fires etc..

Low risk is seen in **changes in national governmental policies**. This is because main national government policies are related to EU policies and, as a result, no significant changes in policies are expected. Nonetheless, the prioritisation of policies could vary according to the political changes.

Unexpected aspects or conditions and the MEASURES project can or have already generated **many opportunities**. The MIS data base and project deliverables offer compiled expert experience and measures relevant for the whole Danube. Awareness for migratory fish and ecological corridors has increased at the national level.

The framework established by the MEASURES project creates a starting point for project proposal development and project implementation. This framework could mitigate and buffer local threats and risks (e.g. natural, political) by spreading them over the networks and larger areas.

Local networks facilitate quick and simple access to expert information on migratory fish and ecological corridors or other related fields. They also promote faster communication and reaction along established tracks. As open structures, local networks can integrate additional actors and fields of expertise, communicate with other networks and institutions, and mitigate the negative effects of individual personnel fluctuations or the drop-out of institutions as a whole. They can also function at low intensity (along the lines of existing expertise and daily tasks), even without additional funding apart from personnel resources, which

are offered by institutions to delegate their employees to meetings etc.

Part of the measures set out in this Strategy for the conservation of the ecological corridor can benefit from funds based on one of the priority objectives: the "restoration of river continuity" of the EU Biodiversity Strategy 2030.

In conclusion, certain risks can have a negative impact on the good implementation of the Strategy, but the opportunities should not be underestimated or lost.

08 Date of expiry and provision for an update

The recommendation is to update the Strategy and action plans in 2027 at the latest. This would enable following the revision cycle of important management documents such as the RBMPs. The coordinators of Local Migratory Fish Networks are slated to meet once per year, and the necessity for and processes of an update shall be discussed and decided then.

09 Annexes

9.1 Glossary

activity – in this document, part of a "Type of measure"

adult – a fish after reaching maturity

alluvial – sediment deposited by rivers, floods and water in general

anadromous – fish which migrate up rivers from the sea to spawn

barbel zone – European river zonation: lowland river stretches, retaining some characteristics of upland rivers such as a gentle gradient with moderate water flow and temperature, good oxygen content and a mixed substrate of silt and gravel. The Barbel (*Barbus barbus*) often is a dominating fish species.

benthi-insectivorous – fish or animals in general feeding on bottom-dwelling organisms and insects and their larvae

biodiversity – the variety of plant and animal life in the world or in a particular habitat, a high or natural level of which is usually considered to be important and desirable, as it is associated with a higher stability, productivity and recovery potential of a respective ecosystem

biota – the animal and plant life of a particular region, habitat, or geological period

broodstock – a group of mature fish used for breeding purposes

Carpathian Convention – the Framework Convention on the Protection and Sustainable Development of the Carpathians

CITES – Convention on International Trade in Endangered Species of Wild Fauna and Flora

coded wire tag – an animal tagging device, consisting of a magnetised stainless steel wire, most often used for identifying batches of fish

connectivity – in this document, the physical or ecological connectedness of river stretches, habitat and populations

conservation – saving and protecting a still natural or nature-like habitat and all of its components

continuity – in this document, the uninterrupted presence of life cycle- and habitat use- supporting conditions, resources, habitat and populations

controlled propagation – (artificial) production of individuals of a species; in the context of this document, generally within a managed environment, for the purpose of supplementing or augmenting wild populations, or reintroduction to the wild to re-establish populations

cyprinid – fish belonging to the family of soft-finned freshwater fishes including carp and minnows (Cyprinidae)

Danube Sturgeon Task Force – an initiative established in January 2012 within the framework of the macro-regional EU Strategy for the Danube Region (EU-SDR) Priority Area 6 (Biodiversity)

DANUBEPARKS – a network of protected areas from 9 countries

DANUBEPARKS connected – a project to bridge the Danube Protected Areas towards a Danube Habitat Corridor

detriti-herbivorous – fish or animals in general feeding on dead organic material and plant material

diadromous – fish migrating between salt and fresh waters for spawning (see also anadromous)

ecological corridor – entity of a river catchment which comprises physical connectivity, habitat connectivity as well as viable populations of fish or animals in general

endemic – a plant or animal native and restricted to a certain place or region

environmental niche – aka ecological niche: the match of a species to specific environmental conditions

Espoo Convention – Convention on Environmental Impact Assessment in a Transboundary Context

estuarine – relating to an estuary, a partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea

European Green Deal – a set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral in 2050

eurythermal – fish or animals and plant in general able to tolerate a wide range of temperatures

eurytopic – a plant or animal found in a wide range of environments, and thus widely distributed

ex-situ conservation – the preservation of components of biological diversity (e.g. animals) outside their natural habitats

ex-situ measures – measures referring to ex-situ conservation

Fish Migration Foundation – a non-profit organisation dedicated to the preservation and restoration of migratory fish species and free-flowing rivers around the world

fisheries (and their organisations) – activity of raising or harvesting fish and other aquatic life

flagship species – a species chosen to raise support for biodiversity conservation in a given place or social context; often species which have high societal value or recognition, such as sturgeons

flood protection – methods and activities used to reduce or prevent the detrimental effects of flood waters

floy external T-bar anchor tags – external mechanical tag for fish

fluvial – referring to processes associated with rivers and streams

functionally extinct – the loss of a population's viability

gene-pool – the total genetic diversity found within a population or a species

grayling zone – European river zonation: upland river stretches with a steep gradient, fast-flowing water, cool temperature and hard bottom substrates (rocks, gravel). The fast flow rate causes turbulence which keeps the water well oxygenated. Fish species found in this zone usually lay adhesive eggs that can stick to the substrate. The European grayling (*Thymallus thymallus*) often is a dominating species.

Green Infrastructure – a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services in both rural and urban settings

habitat connectivity – (seasonal/discharge-dependent) connection of habitats which allows for movements of migratory fish for spawning, wintering, feeding, etc.

hydrological runoff regime – the distribution of water runoff over time in a watershed

hydropower – power (electricity) derived from the energy of falling or fast-running water

insecti-piscivorous – fish or animals in general feeding on insects and their larvae as well as on fishes

insectivorous – fish or animals in general feeding on insects and their larvae

in-situ conservation – the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings

Interreg-Danube Transnational Programme – a financing instrument of the European Territorial Cooperation (ETC), better known as Interreg, providing a framework for the implementation of joint actions and policy exchanges between national, regional and local actors from different Member States. The Danube Transnational Programme (DTP) promotes economic, social and territorial cohesion in the Danube Region through policy integration in selected fields.

juvenile – a young fish after losing larval traits and before becoming mature

key habitat – a habitat type that is essential

for the completion of the life-cycle of a fish species

lacustrine – of or relating to lakes

LIFE project – project under the EU LIFE programme

limnopar – fish or animals in general which reproduce in stagnant water

lithopelagophilic – fish or animals in general which spawn close to hard substrates, spawn drifts in the water column

lithophilic – fish or animals in general which spawn on hard substrates (rocks, gravel)

littoral – referring to the shore of a water body

Local Migratory Fish Networks – in this document, the basic units working to implement the Strategy for ecological corridor conservation in the Danube catchment

Lower Danube – the Danube River between the Black Sea and the Iron Gate gorge, including the delta

marine – of or relating to the sea or the plants and animals that live in the sea

Middle Danube – the Danube River between the Iron Gate gorge and the Devin Gate (between Hainburg and Bratislava)

migratory – of or relating to migration

National Activity Plans for Migratory Fish Species – in this document, plans by the Local Migratory Fish Networks to implement the Strategy for ecological corridor conservation in the Danube catchment or parts of it

navigation – the transport of people (passengers) or goods (cargo) via waterways in the context of this document

omnivorous – fish or animals in general feeding on a variety of food of both plant and animal origin

pelagic-neritic – fish or animals in general spawning in the water column still reached by sunlight

physical connectivity – longitudinal connection of river corridors which allows movement of migratory fish for spawning, wintering, feeding, etc.

phytophilic – fish or animals in general spawning on plants

piscivorous – fish or animals in general feeding on fish

PIT tag – an internal tag for animals (a passive integrated transponder)

potamal – referring to the lower stretches of a stream or river

potamodromous – fish moving and completing the life-cycle in freshwater exclusively

Priority Area (PA) 4 (Water Quality) – one of 12 priority areas within the European Strategy for the Danube Region

Priority Area (PA) 6 (Biodiversity and Landscapes, Quality of Air and Soils) – one of 12 priority areas within the European Strategy for the Danube Region

rheopar – fish spawning in flowing water

rheophilic – fish preferring or living in flowing water

rhithral – referring to the upper stretches of a stream or river with fast-flowing, well-oxygenated water

riparian – relating to or situated on the banks of a river

riverine – relating to or situated on a river or riverbank

stagnophilic – fish or animals in general preferring to live in stagnant water

stenothermal – fish or animals in general capable of surviving over only a narrow range of temperatures

Sturgeon 2020 – a strategy and programme for the protection and rehabilitation of the Danube sturgeons by the Danube Sturgeon Task Force

subadult – referring to a fish with adult traits but not being mature

Type of Measure (ToM) – in this document, a category of measures identified in the MEASURES Strategy based on the core tasks of the project; each Type of Measures consists of specific activities

umbrella species – species selected for making conservation-related decisions, typically because protecting these species indirectly protects the many other species that make up the ecological community of its habitat

Upper Danube – the Danube River between its source and the Devin Gate (between Hainburg and Bratislava)

viable populations – self-sustaining populations of migratory fish which are able to move along the river corridor and between habitats to complete their life-cycles.

water management – the activity of planning, developing, distributing and managing the optimum use of water resources

9.2 Abbreviations and acronyms

BC – Bern Convention-Convention on the Conservation of European Wildlife and Natural Habitats

BDS – EU-Strategy for Biodiversity 2030 (BDS)

BOKU – Universität für Bodenkultur, Wien - University of Natural Resources and Life Sciences, Vienna

CBD – Convention on Biological Diversity (CBD)

CMS – Bonn Convention-Convention on the Conservation of Migratory Species of Wild Animals

CWT – Coded Wire Tag

DDNI – Danube Delta National Institute for research and development, Tulcea

DRB – Danube River Basin

DRBD – Danube River Basin District

DRBMP – Danube River Basin Management Plan

DSTF – Danube Sturgeon Task Force

DTP – Danube Transnational Programme

EA – Environmental Assessment

eCOR – Ecological Corridor

EIA – Environmental Impact Assessment

ERDF – European Regional Development Fund

Espoo Convention – Convention on Environmental Impact Assessment in a Transboundary Context

EU-SDR – EU Strategy for the Danube Region, a macro-regional strategy adopted by the European Commission

FD – Flood Directive

HD – Habitat Directive

IAWB – Impact Assessment on Water Bodies, refers to the study "Assessing environmental Impact of Water Bodies" on the application of WFD art 4(7)

ICPDR – International Commission for the Protection of the Danube River

IHG – Institut für Hydrobiologie und Gewässermanagement, BOKU, Wien - Institute of Hydrobiology and Aquatic Ecosystem Management, BOKU, Vienna

IMFN – International Migratory Fish Network

IMSI – Institute for Multidisciplinary Research, University of Belgrade

IPA – Instrument for Pre-Accession Assistance, a programme and financial instrument for EU candidate countries or potential candidate countries

IUCN – International Union for Conservation of Nature

IUU Fishing – illegal, unreported and unregulated fishing (e.g. poaching, bycatch)

JDS – Joint Danube Survey

KU – Karlovac University of Applied Sciences

LMFN – Local Migratory Fish Network

MEASURES project – "Managing and restoring aquatic EcologicAl corridors for migratory fiSh species in the danUbe RivEr baSin"

MSFD – Marine Strategy Framework Directive (MSFD)

N2000 – Natura 2000

NAIK-HAKI – NAIK - Halászati Kutatóintézet, Szarvas - Research Institute for Fisheries and Aquaculture, Szarvas

NAP-MFS – National Activity Plan for Migratory Fish Species

NBS – Nature-based Solutions

NGO – Non-Governmental Organisation

PAN-EU AP – Pan-European Action Plan for Sturgeons under the Bern Convention

RBMP – River Basin Management Plan

REVIVO – Institute for ichthyological and ecological research, Slovenia

SEA – Strategic Environmental Assessment

STURGENE – ex-situ survey to preserve sturgeon genetic diversity in the middle and lower Danube (STURGENE) - project under the EU-SDR START programme

ToM – Type of Measure

TRUNI – Trnavská univerzita v Trnave - Trnava University

WFD – European Water Framework Directive

WSCS – World Sturgeon Conservation Society

WWF – World Wide Fund For Nature

WWF CEE – WWF Central and Eastern Europe

9.3 MEASURES internal documents used

D 1.2.1 – 1.2.5, D 4.3.1 – Deliverables on workshops in T1 and T4, deliverables on stakeholders and national nuclei

D 2.1.2 – Danube Migratory Fish Habitat Manual

D 2.3.1 – Data of pilot habitat mapping

D 2.3.2 – Reports on joint migratory fish habitat mapping pilot actions and testing of methodology

D 3.1.1 – Genetic conservation manual for ex-situ Danube sturgeon live gene stocks to support the development of supportive restocking programmes and maintaining the genetic connectivity

D 3.2.1 – Results of Sterlet broodstock collection and genetic analysis. Detailed list of collected broodstock (biometrical and genetic dataset) providing a genetic basis of further restocking activities

D 3.2.2 – Restocking activities for Sterlet in spring and autumn 2019 including media events, press releases, conferences and interaction with World Fish Migration Foundation

D 3.3.1 – Restocking activity for Russian sturgeon in spring 2019 at the selected restocking points

D 3.3.2 – Population genetic database of Russian sturgeon broodstock

D 3.4.1 – Design for the implementation of two pilot ex-situ gene conservation sites including complete technical facility- and aquaculture system design with cost estimation

D 3.4.2 – Preparation of project proposal and recommended funding sources for the implementation of two pilot ex-situ sites, based on the obtained system design

D 3.4.3 – Report on the visits to three European sturgeon farms

D 4.1.1 – Analysis of Management and Policy Plans

9.4 Literature and documents

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