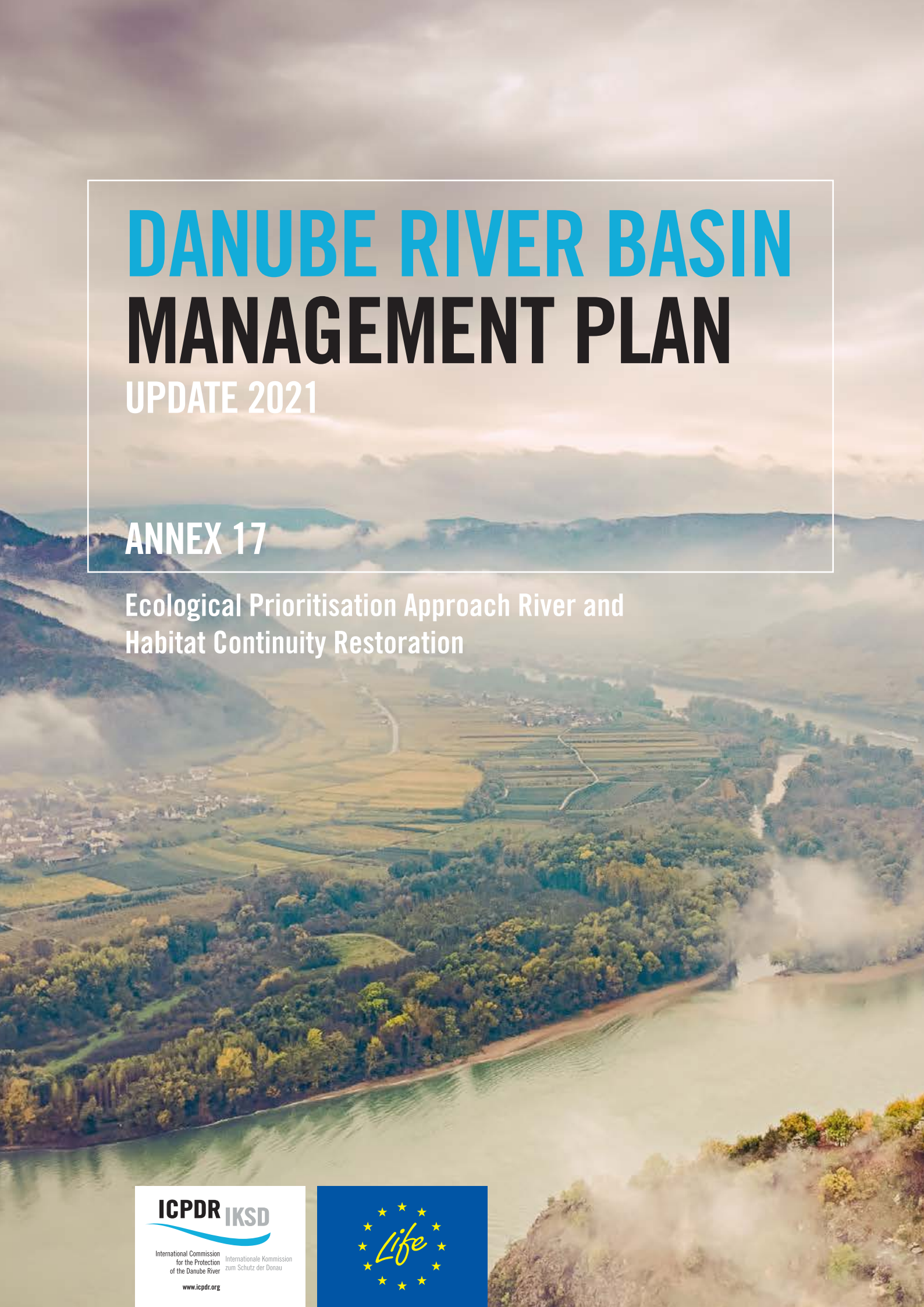
DANUBE RIVER BASIN MANAGEMENT PLAN

UPDATE 2021

ANNEX 17

Ecological Prioritisation Approach River and Habitat Continuity Restoration



ICPDR IKSD
International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau
www.icpdr.org

Life

Table of Contents

1. Introduction

In order to enable a sound estimation of where to target measures most effectively at the basin-wide scale, an ***ecological prioritisation of measures to restore river and habitat continuity*** in the DRBD has been carried out. A respective study has already been performed for the first DRBMP in 2009 and was further developed updated for the DRBMP Update 2015.
At the Danube Ministerial Meeting 2010, the Danube Declaration was adopted, inter alia reconfirming the commitment "*to further develop and make full use of the ecological prioritisation approach for measures to restore river and habitat continuity in order to ensure that they are ecologically most efficient*". The Danube Ministerial Declaration of 2016 underlines "*the need to focus on priority measures taking into account the results of the ecological prioritisation approach for continuity restoration*". In order to take a step in the further development of the approach, discussions have been conducted in the frame of the ICPDR, considering different criteria and rankings. Following data provisions for the DRBMP Update 2021 and further input from Danube countries, the prioritisation index was updated.

2. Objective

All fish species of the Danube River Basin (DRB) are migratory to some extent, however, the importance of migrations for the viability of fish populations considerable vary among species. Migrations are different in terms of migration distances, migration direction (upstream, downstream, lateral), spawning habitats, seasons, life stages, etc. In general, in the DRB migratory requirements are more distinct in lowland than in head water fish communities (

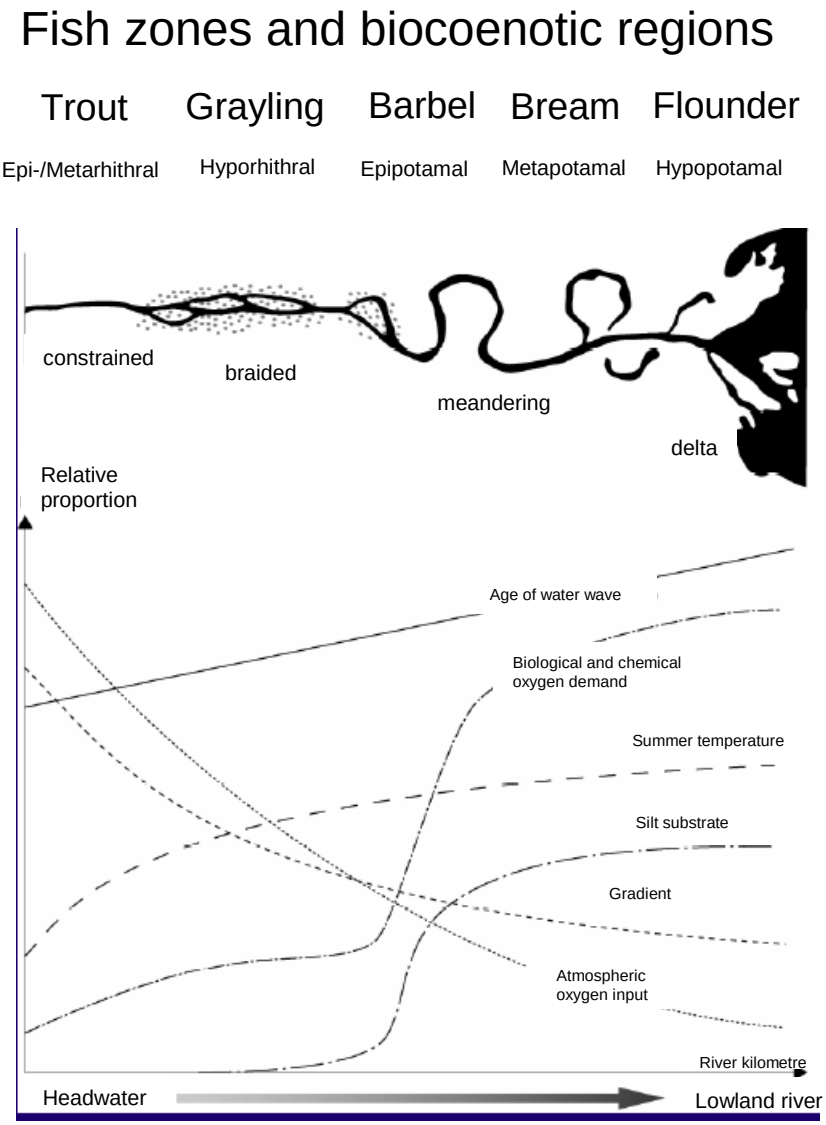
Figure 1).

Long-distance-migrants (LDM) such as the Beluga sturgeon (*Huso huso*) migrated up to several thousand kilometres from the Black Sea to the Barbel zone in the DRB. Medium-distance-migrants (MDM, so called potamodromous fish species) like nase (*Chondrostoma nasus*) and barbel (*Barbus barbus*) migrate within the river over distances of 30 to 200 km (Waidbacher & Haidvogl 1998). A significant number of lowland fish species depend on floodplain spawning habitats during spring season. Contrarily, headwater fish species migrate comparable short distances as living and spawning habitats are mostly not far away. To ensure the achievement or the maintenance of the good ecological status on a long term, all species need an open continuum for e.g. recolonization after catastrophic events and genetic exchange.

The Vision stated in the DRBMP Update 2021 envisages the "Construction of fish migration aids and other measures at existing migration barriers to achieve/improve river continuity in the Danube River and in respective tributaries to ensure self-sustaining sturgeon populations and specified other migratory fish populations". The overall goal of continuity restoration in the DRBD should be free fish migration routes within the entire DRB. However, due to the high number of barriers and limited resources a prioritisation of measures is necessary. The ecological prioritisation approach provides indications on a step-wise and efficient implementation of restoration measures on the basin-wide scale. The approach provides useful information on the estimated effects of the national measures in relation to their ecological effectiveness and could serve as a supportive tool for future measure implementation. Therefore, it also supports the

feedback from the international to the national level and vice versa in the DRB. The ecological prioritisation approach represents an important component for River Basin Management Planning and could constitute an important basis for discussions on measures addressing river and habitat continuity interruptions within the Joint Programmes of Measures (JPM).

Figure 1: Fish zones and abiotic conditions in running waters (adapted from Jungwirth et al. 2003)



3. Distribution of long- and medium-distant migrants in the Danube River Basin

3.1 Methodology (LDM and MDM in the DRB)

Historic upstream occurrence of long-distance migrants (LDM) of riverine fish in the DRB is dominated by sturgeon species as those species are known to have migrated long distances within the Danube catchment. A sturgeon migration map provided by the ICPDR was compared and updated with recent literature reviews and results of the EU-project EFI+ (Evaluation and improvement of the European Fish Index, http://efi-plus.boku.ac.at) (Schmutz & Trautwein 2009).

The potential distribution (habitat) of MDM was modelled using data from the EU-project EFI+ including data from the DRB and other catchments in Europe. Within the frame of the EU-project EFI+ most of the European fish species have been classified according to their migratory behaviour, i.e. long-distance-migrants (LDM see Table 1), medium-distance-migrants (MDM see Table 2) and resident species (RS). Out of the 58 fish species classified as MDM 9 key species were selected occurring in the DRB (Tab. 2) (Schmutz & Trautwein 2009).

Table 1: Examples for long distance migrants (LDM) in the DRB (based on EFI+ guild classification, see http://efi-plus.boku.ac.at)

Nr.	Sientific name	English name
1	*Huso huso*	Great stugeon, beluga
2	*Acipenser guldenstaedti*	Russian sturgeon
3	*Acipenser nudiventris*	Ship sturgeon
4	*Acipenser stellatus*	Stellate sturgeon
5	*Alosa caspia*	Caspian shad
6	*Alosa immaculate (pontica)*	Pontic shad

Table 2: List of medium-distance migrants (MDM) in the DRB (based on EFI+ guild classification, see http://efi-plus.boku.ac.at) used for modelling habitat of MDM in the DRB

Nr.	Scientific name	English name
1	*Abramis brama*	Common bream
2	*Abramis sapa*	Danubian bream
3	*Acipenser ruthenus*	Sterlet
4	*Aspius aspius*	Asp
5	*Barbus barbus*	Barbel
6	*Chondrostoma nasus.*	Nase
7	*Hucho hucho*	Danube salmon
8	*Lota lota*	Burbot
9	*Vimba vimba*	Vimba

The consolidated EFI+ database comprises about 10,000 sites all over Europe. About 1,000 sites are located in the DRB. Unfortunately, the number of sites from the Danube catchment with occurrence of MDM is small (379 sites) and not sufficient for model calibration. Therefore, data from additional European catchments comparable with the DRB was used. By restricting the selection of data to Illies's ecoregions 3

to 16 we tried to avoid a bias from Mediterranean (Iberian) and Nordic (Scandinavia) influences, as the distribution of MDM might follow different rules in those areas. Out of the resulting 3,800 sites Schmutz & Trautwein (2009) selected all sites (1,268 sites) where MDM were recorded and randomly a similar sized set of data from sites where MDM did not occur. In total, about 2,500 sites were used to calibrate the model.

Regression Tree techniques were used for modelling MDM occurrence as this technique allows using also non-normally distributed data. All modelling was done with the open source software R®. The Regression Tree function of R® (rpart) includes an internal validation as the variable selection and splitting process is repeated 500 times. The results were additionally validated by using only data from the DRB (Schmutz & Trautwein 2009).

For calculating predictive environmental variables such as catchment size, elevation and river gradient the CCM river model was used developed by the JRC in Ispra (Vogt et al. 2007) which had been also used for the EFI+ project. The CCM is a modelled river network and hence there are slight deviations between the modelled river courses and the real ones. This is mainly true in the headwaters where the CCM sometimes selects different tributaries compared to other maps. Another problem may occur in lowland rivers with very low gradient in plain terrain where the actual and modelled river course may deviate. The deviations do not significantly affect the results as environmental variables used for the modelling are quite stable against river course deviations.

3.2 Results (LDM and MDM in the DRB)

Information on the natural distribution of LDM sturgeon species in the DRB served as a basis (Hensel & Holcik, 1997). According to additional data from the EFI+ project and information received from national fish experts of the DRB contacted via the ICPDR slight changes of the original ICPDR maps have been made for the first approach (Schmutz & Trautwein 2009): The occurrence of sturgeon species in the Isar river (Bavaria) was restricted to the lower part of the river. LDM sturgeon occurrence has been added to the lower Inn river and lower Salzach river (Austria). For the DRBMP Update 2021, the lower part of Zagyva river was changed from LDM to MDM.

The modelled distribution of the MDM in the DRB using Regression-Tree analyses shows that the presence and absence of medium-distance migrants (MDM) is mainly determined by the size of the catchment (Figure 2). River segments with upstream catchment areas (AREA_ctch) less than 284 km^2 have a very low probability of MDM. In addition, river segments with an upstream catchment size of less than 1,401 km^2 and a mean elevation of the upstream catchment (ELEV_MN_du) of more than 819 m have also a low probability of MDM. All other river segments have a high probability of occurrence of MDM. The model explains the variability of probability of occurrence by about 42 %. Applying the model to the data, presence and absence can be explained by about 82 % and 78 %. Applying the model to the data from the DRB reveals similar predictions of presence (78 %) and absence (81 %) approving the applicability of the model to the DRB. Figure 2 clearly shows the separation between the habitat of the LDM, MDM and the head waters above the MDM in the DRB. Results of modelled MDM habitat were checked by the countries of the DRB and only minor deviations from the real conditions were reported and included in the final map (Schmutz & Trautwein 2009). For the DRBMP Update 2021, the upper part of Zagyva river was changed from MDM to headwater. Furthermore, since Sio felso (downstream of lake Balaton) is intermittent it is not considered as relevant for MDM species.

The MDM habitat, however, was only modelled for rivers with a catchment >4000 km². It is most likely that the MDM habitat extends also in smaller rivers. Therefore, if this criterion is applied on a national level considering also smaller rivers, all MDM-habitats have to be identified.

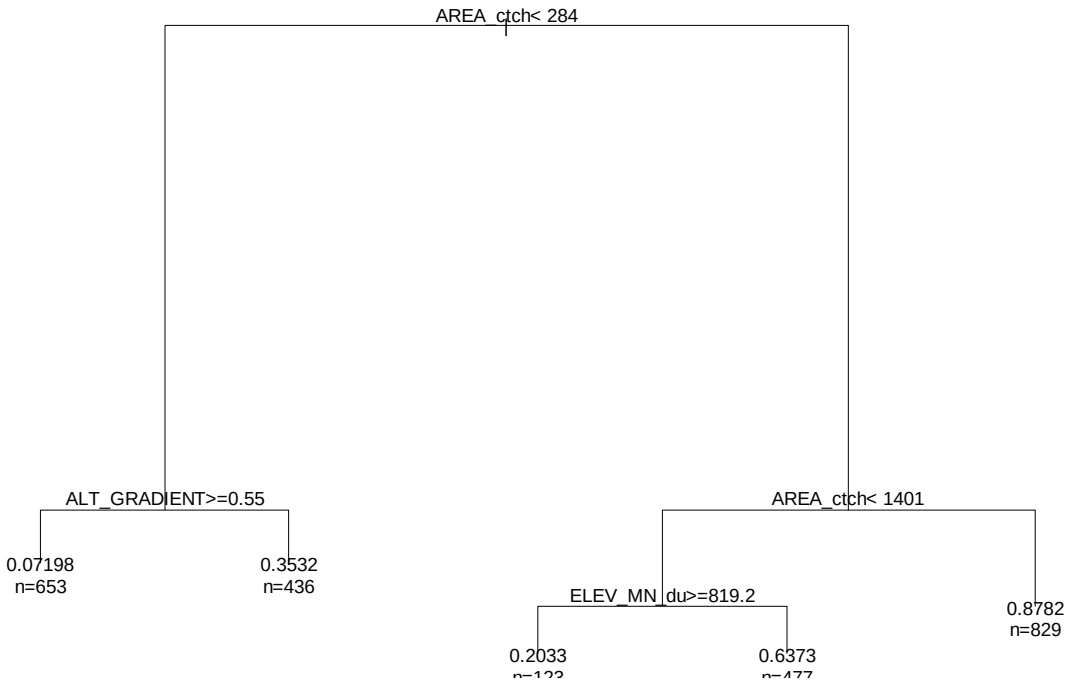


Figure 2: Regression-Tree model for medium-distance migrants using data from the EFI+ project: Probability of occurrence and number sites of each branch (upstream catchment areas: AREA_ctch, mean elevation of the upstream catchment: ELEV_MN_du, gradient of river segment: ALT_GRADIENT) (Schmutz & Trautwein 2009).

4. Update of the prioritisation approach of the Danube River Basin

Although the application of different methodologies (GIS approach, optimisation approach) was discussed, the scoring and ranking method (as used in the DRBM 2009 Schmutz & Trautwein 2009) and in the DRBMP Update 2015 (Mielach & Schmutz 2015) was extended by hydrological pressures and again applied in the updated version. It has the advantage of transparency and comprehensibility and allows a direct comparison with the results included in previous DRBM Plans.

Besides ecological criteria, also the inclusion of other economically/ technical criteria was discussed with the result, that such criteria can be incorporated on a national level but the basin-wide prioritisation approach should focus on ecological criteria.

4.1 Methodology

The following chapters describe the process of barrier selection and the calculation of individual criteria for considered barriers. The following datasets were used for the updated approach.

Table 3: Used criteria and datasets

Used data	Dataset (name)
Continuity interruptions Barriers*	Longcontinterr_pv
River network river water bodies >4000km²* LDM-/MDM-habitat*	DRBMP2021_RWBody4000_l_v
Protected areas water-relevant habitat protection areas (FFH)* water-relevant bird protection areas* other Nature protection areas for water-dependent species and water-related habitats (WFD Art. 5)*	pa_habitat_pv pa_bird_pv pa_other_pv
Hydro-morphological pressures segment with impoundment** segment with hydro peaking** segment with water abstraction**	Hydroaltimp_pv rwbody4000_hydroaltpeak_pv rwbody4000_hydroaltabs_pv

* Original criteria already used for the DRBMP 2009
** Criteria added for DRBMP Update 2021

4.1.1 Continuity interruptions

The dataset (longcontinterr_pv) includes a total of 967 longitudinal continuity interruptions. At the moment, barriers within the LDM-habitat are, if at all, only equipped with fish passes supporting migrations of MDM-species. While these barriers are passable for MDM-species, it has to be assumed that they are still impassable for large sturgeons. Therefore, these barriers were included in the prioritisation index calculation and highlighted in the map to show their current status (i.e. MDM-fish pass in LDM-habitat). Since there are no standardised fish pass solutions for LDM-species, individual measures have to be taken. The adaptation of existing fish passes in Austria and Germany to allow the passage of large sturgeons will be necessary when these species are able to reach the respective barriers, which means, when the Iron Gates

and Gabčikovo are passable. A respective step-wise approach for continuity restoration is described in the DRBMP Update 2021.

Consequently, all barriers within the LDM-habitat (i.e. 96) and all impassable barriers (i.e. without fish pass) within the MDM (390) were defined as relevant for the prioritisation approach (see Table 4).

Table 4: Identification of barriers relevant for the Prioritisation Index calculation

	No fish migration aid (values 0; 8; G, N, U)	Fish migration aid (value Y)	Total
LDM Danube	14*	7*	21
LDM tributary	55*	20*	75
MDM	390*	251	641
Headwater	196	34	230
Total	**655**	**312**	**967**

* barriers relevant for Prioritisation Index calculation (n = 486)

4.1.2 Main migration routes

The main migration routes of long and medium-distant migratory species as modelled for the prioritisation approach included in the 1st Danube River Basin Management Plan (see chapter 3) were adopted for the updated version. The LDM- and MDM-habitat information was furthermore transferred to the river body network of the ICPDR (RW-Body4000).

The prioritisation principle follows the idea that LDM within the Danube receive the highest priority followed by LDM within the tributaries. MDM receive less priority and head waters which are typical habitats for short distance migrators are excluded from the prioritisation process. Therefore, priorities are considered as follows:

- Long distance migrants habitat in Danube (rating = 4)
- Long-distance migrants habitat in Danube tributaries (rating = 2)
- Medium-distance migrants habitat (rating = 1)
- Short-distance migrants (head waters) (rating = 0)

4.1.3 Location of the barrier (distance from mouth)

Since long- and medium distance migratory fish usually migrate from downstream to upstream, obstacles at the mouth of a river receive higher priority than upstream obstacles and giving more emphasis on the main river (e.g. Danube) than on the tributaries. The more distant an obstacle is located from the river mouth the less priority is given to the obstacle. The two criteria “obstacle in first river segment upstream of river mouth” and “distance from mouth” were already included in the 1st approach. By adding up the individual rankings, the criteria were combined in the updated approach and show the following rankings:

- Obstacle in first fragmented river segment in the Danube upstream of Danube delta (rating = 5)
- Obstacle in first river segment upstream of mouth (rating = 4)

- Obstacle in second river segment upstream of mouth (rating = 2)
- Obstacle in third river segment upstream of mouth (rating = 1)
- Obstacle in segment upstream of third river segment (rating = 0)

River segments are defined as the river stretch between two tributaries. Segments classification in the Danube-tributaries is based on the CCM-river network, which are calculated on the basis of a DEM with 100m resolution[1] (Vogt et al. 2007). The highest priority is given to the barriers at Iron Gate, since these barriers represent the most downstream barriers within the Danube itself.

4.1.4 Reconnected habitat length

In order to achieve the highest ecological effects, higher weight is given to river stretches that are less fragmented by continuity interruptions. The reconnected habitat for each barrier was calculated by adding up the distance to the next up- and downstream barrier, whereby only relevant barriers (i.e. all barriers in the LDM- and all impassable barriers in the MDM-habitat) were considered. The distance was only calculated within the LDM-/ MDM-Habitat and the river, where the barrier was located. For the most downstream barrier within a tributary or the Danube (e.g. Iron Gate), the distance to the confluence/delta was used instead of the distance to the next downstream barrier.

For this criterion different river length classes for the Danube and the tributaries were defined. Based on experiences in the Danube, the following thresholds were defined by expert judgement:

- >50 km (>100 km Danube) (rating = 2)
- 20-50 km (40 – 100 km Danube) (rating = 1)
- <20 km (<40 km Danube) (rating = 0)

4.1.5 Protected site (Natura2000) or national protection site

Apart from the WFD relevant criteria, additional criteria stemming from EU legislation like Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora was used, requiring to achieve a favourable conservation status in Natura 2000 areas. Considering that fish species and habitats are also part of the Natura 2000 goals it is reasonable that the protection status also should be considered in the prioritisation approach.

Obstacles within a distance of 500 m of water-relevant Natura 2000 areas which are important for fish receive higher priority as it is more likely that those river segments are maintained in good habitat status or will be restored earlier than unprotected river segments, thus providing good habitat quality. For non-EU member states, other protected areas are used as a substitute for Natura 2000 areas. Therefore, higher priority is given to barriers located within or close (i.e. <500 m) to a water-relevant protection site.

- Barrier within/close to water-relevant Natura 2000 or other protected area (rating = 1)
- Barrier with greater distance to protected areas (rating = 0)

4.1.6 Anthropogenic pressures

In 2015, the prioritisation approach was extended by an additional criterion representing anthropogenic pressures. With regard to impoundments, hydropeaking and water abstraction, it was assessed whether a water body is impacted by these pressures or not. Since more detailed information (e.g. the exact location

[1] River segments are available for download here: https://ccm.jrc.ec.europa.eu/

and length of the respective pressures) is not available for all pressures, the number of pressures were summed up per water body and then transferred to the barriers within the water body.

Although also "morphological alterations" were considered as relevant for the prioritisation approach, there is no uniform morphology classification scheme available in the Danube catchment at the moment. While some countries classified the morphological condition of their river water bodies with "1" (i.e. high) and "2-5" (i.e. good-bad) others used a more detailed classification of "1-2" (i.e. high-good), "3" (i.e. moderate) and "4-5" (i.e. poor-bad). Therefore, only three pressure types (i.e. impoundments, water abstraction and hydro peaking) were used for the prioritisation index calculation.

In summary, the following criteria and ratings were used for the calculation of the new prioritisation index.

Table 5: Criteria and their ratings for the Prioritisation Index calculation

Criteria	Rating
1. Migratory habitat	
- Long-distance migrants habitat (Danube)	4
- Long-distance migrants habitat (tributary)	2
- Medium-distance migrants habitat	1
- Short-distance migrants habitat (head waters)	0
2. River Segment	
- First river segment in Danube	5
- First river segment upstream of mouth (tributary)	4
- Second river segment upstream of mouth	2
- Third river segment upstream of mouth	1
- River segments upstream of third river segment	0
3. Length of reconnected habitat (Danube/tributary)	
- >100 km / >50 km (tributary)	2
- 40-100 km / 20-50 km (tributary)	1
- <40 km / <20 km (tributary)	0
4. Protected site	
- Yes	1
- No	0
5. Pressures	
- 0 pressures	3
- 1 pressure	2
- 2 pressures	1
- 3 pressures	0

The selection of prioritisation criteria for continuity restoration was mainly based on the migratory behaviour of LDM and MDM in the DRB. The prioritisation principle follows the idea that LDM within the Danube receive the highest priority (weight 4) followed by LDM within the tributaries (weight 2). MDM receive less priority (weight 1) and head waters are excluded from the prioritisation process (weight 0). Within this prioritisation framework obstacles at the mouth of a river receive higher priority than upstream obstacles whereby a special focus is given to the most downstream barriers in the Danube. The more distant an obstacle is located from the river mouth the less priority is given to the obstacle. In order to give higher weight to river segments that are less fragmented by continuity interruptions, the length of the reconnected habitat depending on the length of river segments was weighted. For this criterion different river lengths

classes for the Danube and the tributaries were defined to consider the river size. The final criterion is related to the protection status. Obstacles within water-related protected areas of the NATURA2000 network and other protected areas for non-EU Member States receive higher priority as it is more likely that those river segments are maintained in good habitat status and will be restored to a larger degree than un-protected river segments. Finally, the new prioritisation index also considers anthropogenic pressures, whereby barriers in less impacted water bodies (0-1 pressures) received higher ratings than barriers in impacted water bodies (2-3 pressures).

Again, the criteria were combined by computing the prioritisation index (PI) by weighting the first criterion (migratory habitat) by the cumulated weight of the other criteria.

PI_{new} = migratory habitat x (1 + barrier location + reconnected habitat length + protected site + anthropogenic pressures)

4.2 Results

The downstream – upstream prioritisation concept is clearly visible in the map of prioritisation (see Map 40 in the DRBMP Update 2021). In total, out of 967 barriers, 481 were excluded since they were located in headwaters or already equipped with a suitable fish pass (i.e. MDM fish pass in MDM-habitat). The remaining 486 barriers were considered as relevant for the prioritisation index calculation. It has to be considered, that some barriers were reported twice (i.e. where the river represents the national border between countries), whereby the barrier with the higher prioritisation index (if this applies) is shown on-top of the other. Further harmonization is required, to eliminate related errors.

The results show that according to the defined prioritisation criteria continuity disruptions in the Lower Danube (Iron Gates, 2 barriers with 2 entries) receive the highest priority with values ≥ 40. Those barriers are considered of utmost priority for LDM species. Also, in the Upper Danube two barriers with utmost priority for LDM- and MDM-species are found. Furthermore, 16 barriers are considered of very high, 22 of high, 114 of medium and 328 of low priority.

4.2.1 The ecological prioritisation approach **and sturgeon habitats** in the Danube River Basin

The results of the prioritisation index are also reflected in the habitat assessment of the Danube sturgeons within the MEASURES project. The connectivity of the current habitat of LDM in the Lower Danube and vast potential habitats in the Middle Danube are of utmost priority for the conservation and restoration of these species. The prioritisation approach as presented here, clearly supports the coordination of the complex topic of sturgeon conservation on a basin-wide scale. The MEASRUES project identified river continuity as one of the most urgent priorities to establish ecological corridors. Especially the barriers at the Iron Gates and at Gabčikovo separate the Upper, Middle, and Lower Danube into unconnected sections.

The following table shows the results of the classification. The maximum possible value of the prioritisation index is 44 and the minimum is 0 (for barriers in head waters or passable barriers). The prioritisation index was grouped into 6 classes: utmost priority for LDM (>30), utmost priority (21-30), very high priority (16-20), high priority (11-15), medium priority (6-10), low priority (1-5).

Table 6: Results of the updated prioritisation index

Priority	Prioritisation Index I	barriers (total)	thereof with MDM-fish pass in LDM habitat
utmost priority for LDM	44	4(2)	
utmost priority			
	24	2	
very high priority	20	11	6
	18	1	
	16	4	1
high priority	12	22	8
medium priority	10	25	4
	9	1	
	8	18	5
	7	13	
	6	57	3
low priority	5	100	
	4	141	
	3	69	
	2	15	
	1	3	
Not applicable	-	1	
no priority	-	480	
with fish pass	-	229	
total		967 (965)	27

Table 7: Number of barriers per criterion (only barriers with a prioritisation index > 0)

	Criteria rating					
	5	**4**	**3**	**2**	**1**	**0**
Habitat	-	LDM Danube	-	LDM Trib.	MDM	
number of barriers		21		75	390	
Segment	1 Danube	1 Trib.	-	2 Trib.	3 Trib.	>3 Trib.
number of barriers	4	11		4	6	461
Recnonnected length Danube	-	-	-	>100 km	40-100 km	<40 km
number of barriers				10	14	27
Reconnected length Tributary	-	-	-	>50 km	20-50 km	<20 km
number of barriers				85	97	253
Protected site	-	-	-		yes	no
number of barriers					303	183
Pressures	-	-	0	1	2	3
number of barriers			129	289	53	15

5. References

Hensel K. & Holcik J. (1997): Past and current status of sturgeons in the upper and middle Danube River. Environmental Biology of Fishes 48: 184-200.

Jungwirth, M., Haidvogl, G., Moog, O., Muhar, S., Schmutz, S. (2003): Angewandte Fischökologie an Fließgewässern. p552; Facultas Universitätsverlag, Wien; ISBN 3-8252-2113-X.

Mielach C. & Schmutz S. (2015): Update of the ecological prioritisation approach to restore habitat continuity in the DRBD. Annex 13 of the Danube River Basin Management Plan – Update 2015: 15p.

Schmutz S. & Trautwein C. (2009): Ecological prioritization of measures to restore river and habitat continuity in the DRBD, Annex 18 of the DRBMP.

Vogt, J., Soille, P., de Jager, A., Rimaviciute, E., Mehl, W., Foisneau, S., Bodis, K., Dusart, J., Paracchini, M.L., Haastrup, P., Bamps, C. (2007): A pan-European River and Catchment Database. European Commission - JRC, Luxembourg, (EUR 22920 EN) 120 pp.

Waidbacher, H. & Haidvogl G. (1998): Fish migration and fish passage facilities in the Danube: Past and present. -In: Jungwirth, M., Schmutz, S. & Weiss, S. (eds.): Fish Migration and Fish Bypasses. Oxford, -Fishing News Books: pp.85-98.