Ecological prioritisation of measures to restore river and habitat continuity in the DRBD

Annex 18 of the DRBM Plan

Deutschland //// Österreich //// Česká republika //// Slovensko //// Magyarország //// Slovenija //// Hrvatska //// Bosna i Hercegovina //// Србија //// Crna Gora //// România //// България //// Moldova //// Україна

Developing a methodology and carrying out an ecological prioritisation of continuum restoration in the Danube River Basin to form part of the Danube River Basin District Management Plan

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Vienna, October 2009

Prepared for the International Commission for the Protection of the Danube River (ICPDR)

1. Objectives

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 (Fig.1). Long-distance-migrants (LDM) such as beluga (*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. Nevertheless, in the long term all species need an open continuum for e.g. re-colonisation after catastrophic events and for genetic exchange.

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 approach provides indications on a step-wise and efficient implementation of restoration measures on the basin-wide scale. It provides useful information on the estimated effects of the national measures in relation to their ecological effectiveness on the basin-wide scale. The approach serves 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. Therefore, the prioritisation tool represents an important component of the DRB Management Plan and will be an essential basis for the hydromorphological component on river and habitat interruptions within the Joint Programmes of Measures (JPM).

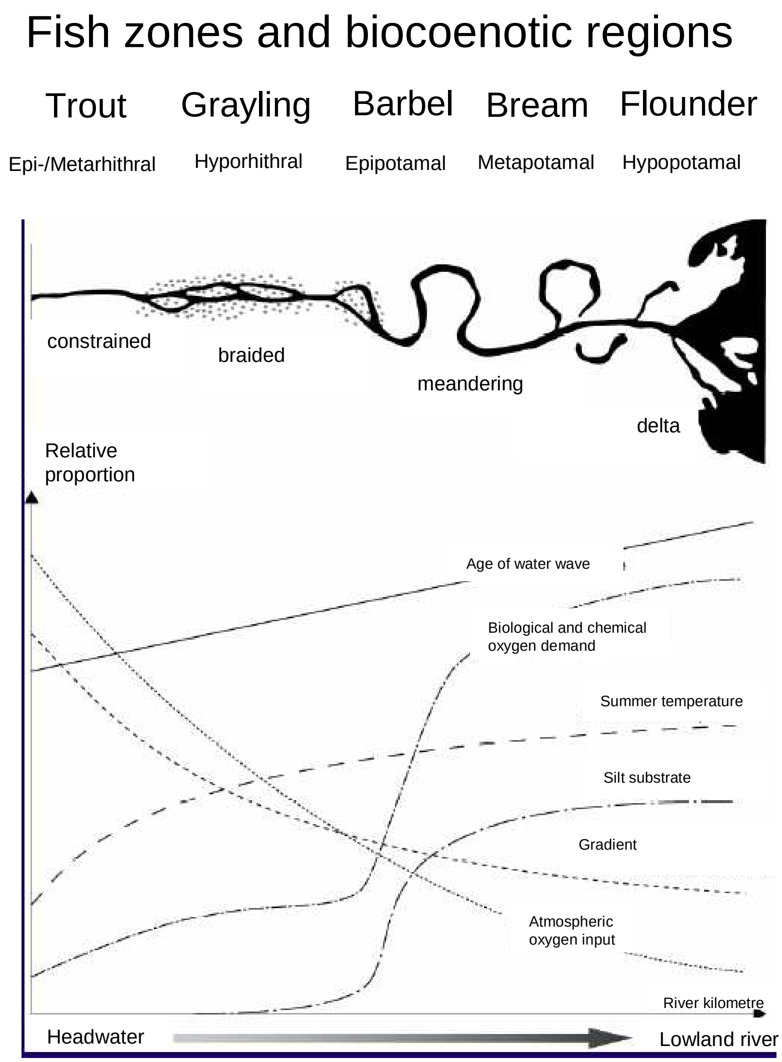

Fig.1: Fish zones and abiotic conditions in running waters (adapted from Jungwirth et al. 2003)

2. Distribution of long and medium-distant migrants (LDM) in the DRB

2.1. Methodology

Historic upstream occurrence of long-distance migrants (LDM) in the DRB is dominated by sturgeon species as those species are known to have migrated further upstream than other species. The historic occurrence of LDMs is based on historical information going back centuries. The historical information serves the definition and use as reference conditions corresponding to entirely or almost entirely undisturbed natural conditions. The distribution of MDMs is based on modelled data that has been calibrated with current information. The 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).

Currently, the information on the distribution of medium-distant migrants (MDM) in the DRB is scarce and incomplete. Therefore, the potential distribution (habitat) of MDM was modelled using data from 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), medium-distance-migrants (MDM) and resident species (RS). Out of the 58 fish species classified as MDM we selected 9 key species occurring in the DRB (Tab. 2).

Tab.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

Tab.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, we used data from additional European catchments comparable with the DRB. 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 we 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.

We used Regression Tree techniques 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.

For calculating predictive environmental variables such as catchment size, elevation and river gradient we used the CCM river model developed by the JRC in Ispra (Vogt et al. 2007) that was 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.

2.2. Results

The figure 3 shows the information on status of historic occurrence of LDM sturgeon species in the DRB. 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: The occurrence of sturgeon species in the Isar river (Bavaria) was restricted to the lower part of the river. LDM sturgeons occurrence has been added to the lower Inn river and lower Salzach river (Austria).

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 (Fig. 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 only the data from the DRB reveals similar predictions of presence (78 %) and absence (81 %) approving the applicability of the model to the DRB. Fig. 3 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.

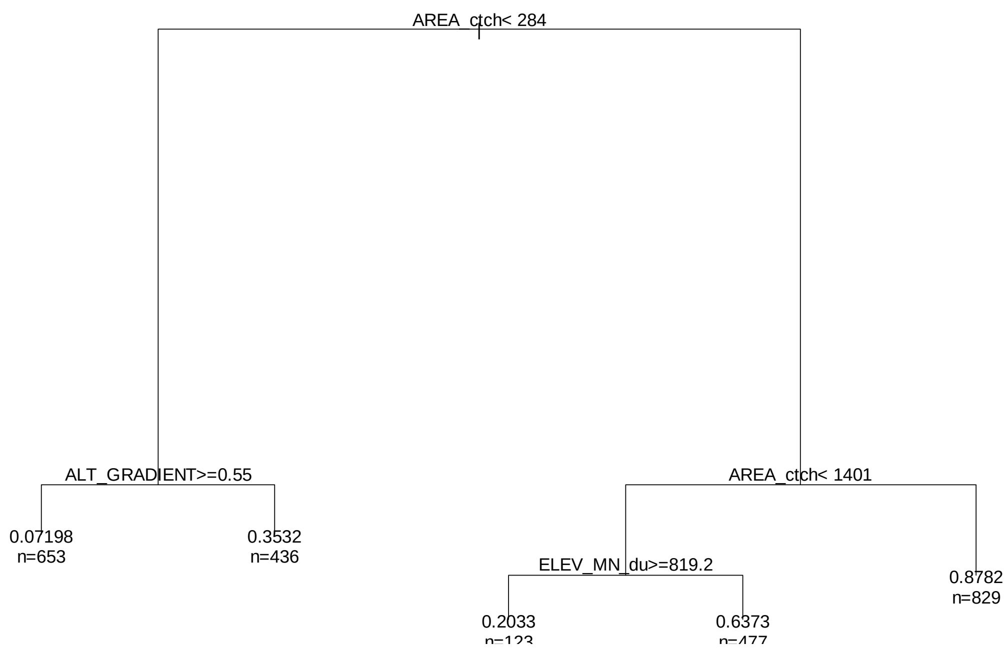

Fig.2: Regression-Tree model for medium-distance migrants using data from the EFI+ project: Probability of occurrence and number sites of each branch (upstream catchment areas: AREA_ctch, mean elevation of the upstream catchment: ELEV_MN_du, gradient of river segment: ALT_GRADIENT).

3. Development of a prioritisation index for restoring continuity

3.1. Methodology

The selection of prioritisation criteria for continuity restoration is mainly based on the migratory behaviour of LDM and MDM in the DRB (Tab.3). 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 and giving more emphasis on the Danube than on the tributaries. 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 we weighted the length of the reconnected habitat depending on the length of river segments. For this criterion we defined different river lengths classes for the Danube and the tributaries to consider river size. The final criterion is related to the protection status. Obstacles within protected areas of the NATURA2000 network 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.

The criteria are combined by computing a prioritisation index (PI) by weighting the first criteria, migratory habitat, by the cumulated weight of the 4 other criteria using the following formula:

PI = migratory habitat x (1 + first obstacles upstream + distance from mouth + reconnected habitat + protected site)

The maximum possible value of the PI is 36 and the minimum is 0 (only in head waters). Finally, the PI was grouped into 5 classes: utmost priority (PI >13), very high priority (PI 10-12), high priority (PI 7-9), medium priority (4-6) and low priority (PI 1-3).

For calculating the PI we used again the CCM river network (Vogt et al. 2006). Rivers with more than 4.000 km² catchment size were extracted from the CCM. Rivers Lech, Altmühl, Crisul Negru, and Somesul Mic were also extracted because they are considered as important rivers in the basin management plan. River segments are defined as the river stretch between two tributaries.

1688 locations of barriers were provided by the ICPDR (status 30. October 2009). The following criteria were applied during preselection for prioritisation (total N=946):

- select barriers not passable for fish in 2009 (FISH_AID = NO OR UNKNOWN). N=932
- select barriers passable in 2009 but within long distant migrants reaches (assuming sturgeons cannot pass fish aid). N=14

Continuity interruptions provided by the ICPDR were allocated to the CCM (snap to closest segment). A number of 85 barriers of 946 for prioritisation could not be allocated because they are situated in artificial water bodies (canals) or there are differences of CCM to the official ICPDR network at the headwaters. Using various GIS tools the first obstacle upstream the mouth, the distance from the mouth, the length of reconnected habitat, and proximity of protected areas is calculated and the PI computed.

1.	**Migratory habitat**	
•	Long-distance migrants Danube	4
•	Long-distance migrants habitat	2
•	Medium-distance migrants habitat	1
•	Short-distance migrants (head waters)	0
2.	**Obstacles in first river segment upstream river mouth**	
•	Yes – in Danube	2
•	Yes	1
•	No	0
3.	**Distance from mouth**	
•	First river segment upstream of mouth	3
•	Second river segment upstream of mouth	2
•	Third river segment upstream of mouth	1
•	River segments upstream of third river segment	0
4.	**Length of reconnected habitat**	
•	>50 km (>100 km Danube)	2
•	20-50 km (40-100 km Danube)	1
•	<20 km (<40 km Danube)	0
5.	**Protected site (Natura2000)**	
•	Yes	1
•	No	0

Tab.3: Prioritisation criteria and weighting factors for restoring continuity in the DRB

An additional criterion, habitat quality of reconnected habitats, could be added in future versions of the PI, when consistent information on habitat quality will be available within the entire DRB.

3.2. Results

The downstream – upstream prioritisation concept is clear visible in the map of prioritisation (Fig. 4). The results show that according to the defined prioritisation criteria continuity disruptions in the lower Danube (Iron Gate) receive the highest priority with values ≥ 20. In the upper Danube the PI ranges between 8 and 16 as long as the Danube is classified as LDM habitat. Within the LDM habitat the obstacles in Bavaria generally receive higher values compared to Austria because longer habitats are reconnected and most obstacles are within Natura2000 areas. Within the tributaries the lowest obstacle and following upstream obstacles generally have a higher PI than obstacles located further upstream. In total, 946 continuum interruptions have been considered. More than a quarter of the barriers (27 %) are not of priority (PI=0) because in headwaters or canals. Out of the 681 prioritised barriers, 39 barriers

(4 %) have a high to utmost priority, 99 barriers (10 %) are of medium and 543 barriers are of low priority (58 %). The importance of upstream located barriers will increase in future when downstream barriers will have been restored (Fig. 4).

The results reveal clear ecological priorities for continuity restoration within the DRB. The proposed prioritisation should used as a guideline whereby the final decision where and when to restore a continuity interruption also depends on the technical feasibility to build fish passes or to find other solutions (e.g. removal of barriers) and will be also determined by the relevance for national restoration and conservation programmes.

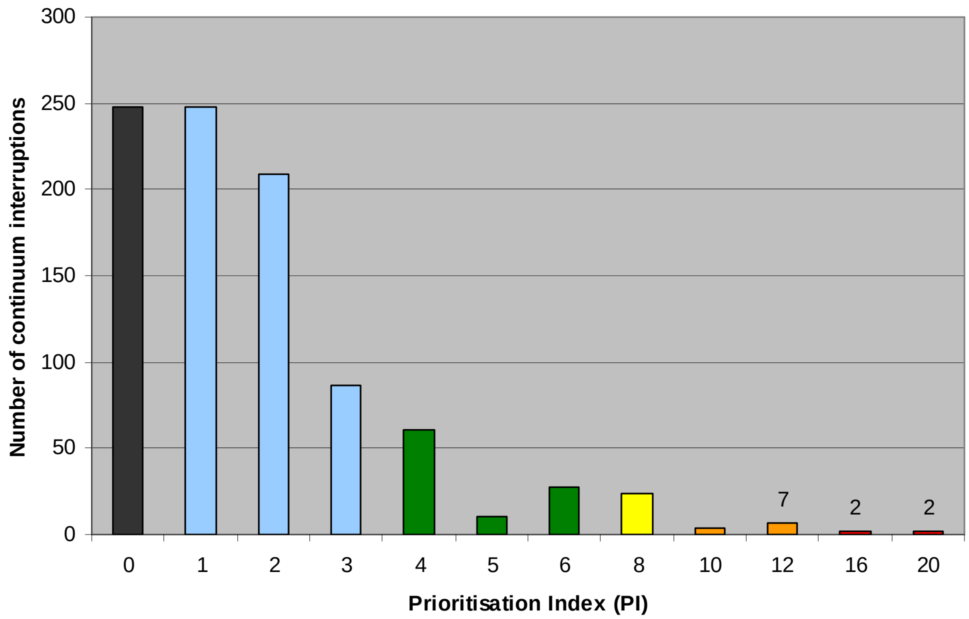

Fig. : Number of barriers per Prioritisation Index (PI)

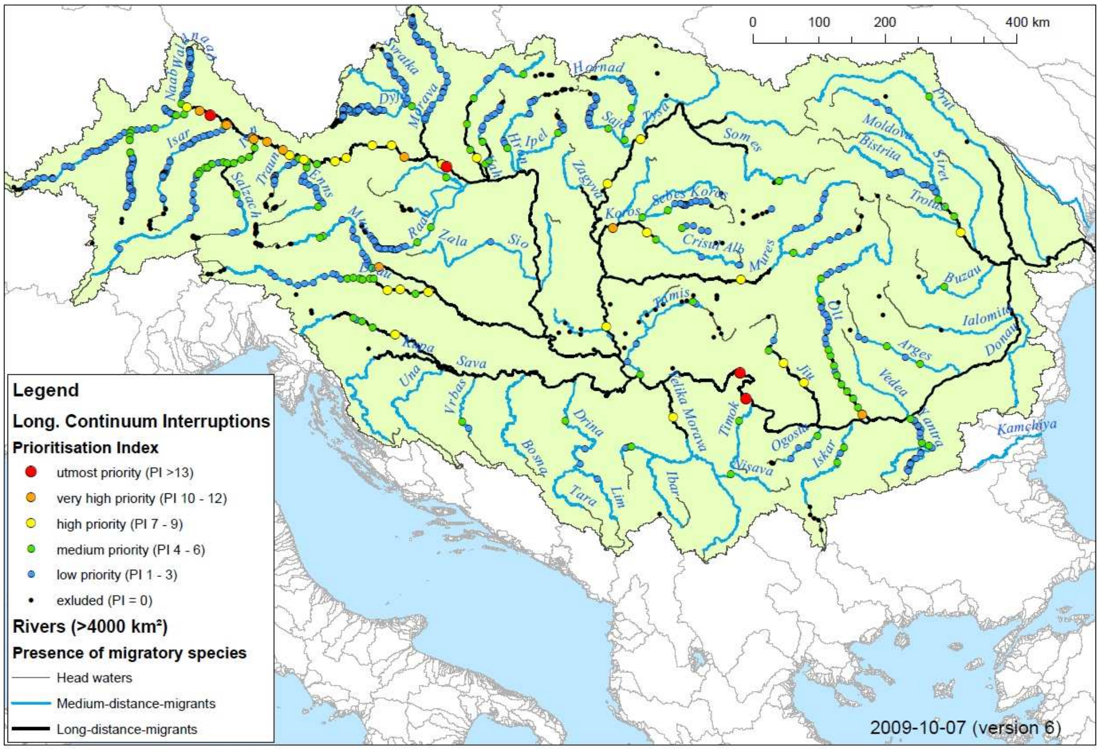

Fig. 4: Prioritised continuity restoration of obstacles within the DRB using the Prioritisation Index (PI) within habitat of long-distance- and medium-distance-migrants

4. References

References

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