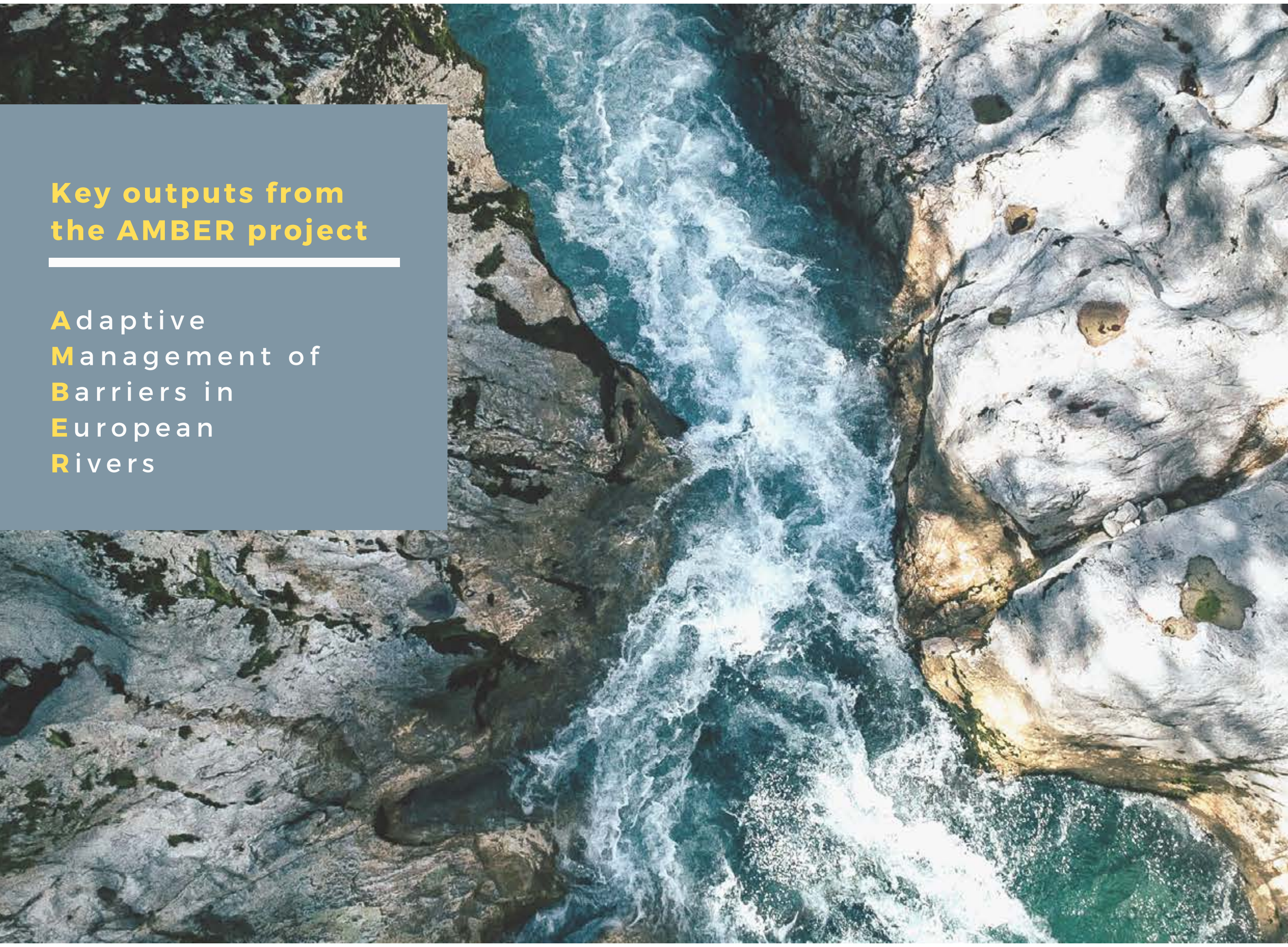
SEPTEMBER 2020

AMBER POLICY BRIEF 1



Key outputs from the AMBER project

Adaptive
Management of
Barriers in
European
Rivers

This policy brief outlines key outputs of WP1 of the H2020 AMBER project

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AMBER

This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 689682

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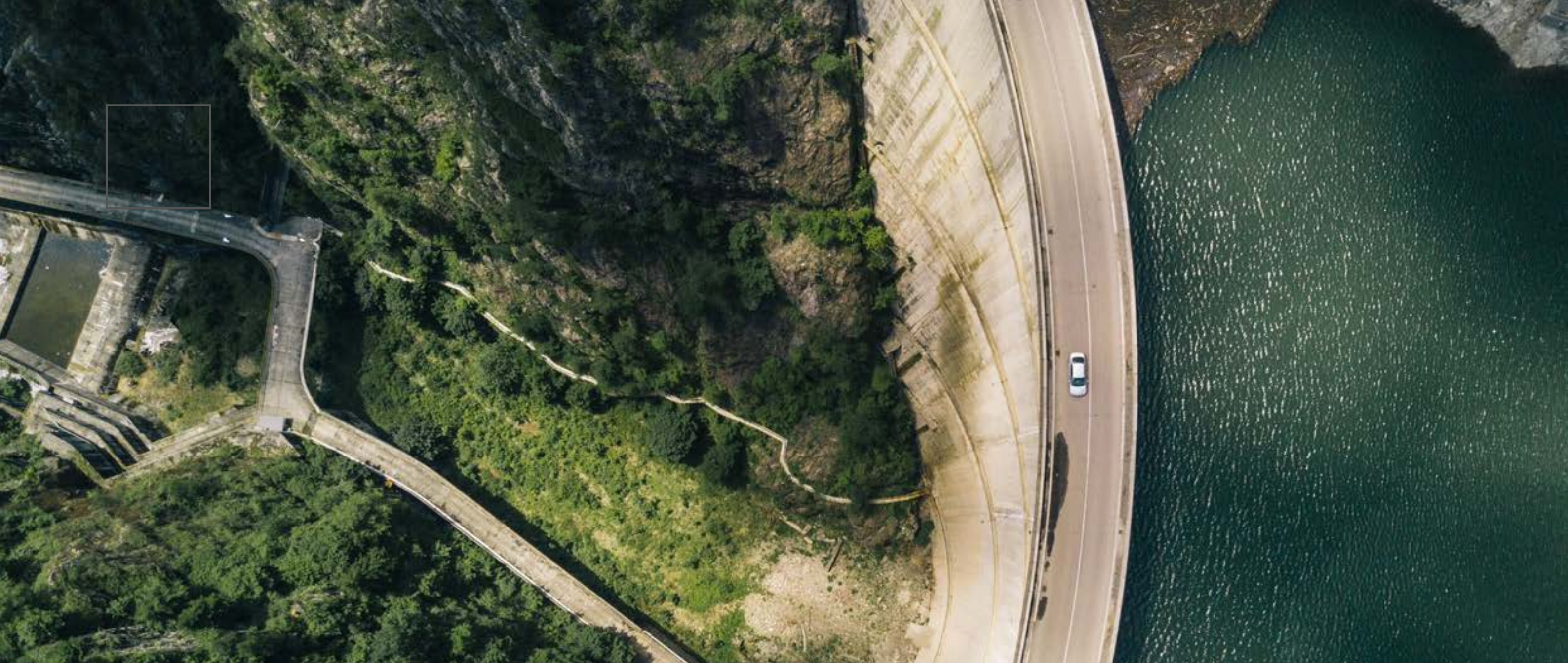


THE NEED

With only one third of its rivers having ‘good ecological status’ Europe has probably more heavily modified rivers than anywhere else in the world, as well as a long legacy of fragmentation. Yet, the extent of river connectivity remains unknown for most European rivers, despite the fact that inventories of physical barriers are required in River Basin Management Plans (RBMP).

Attempts to quantify river fragmentation have been hampered by the absence of a harmonised barrier database and this has in turn prevented efficient restoration of river continuity.

MEETING THE NEED

We present the first comprehensive estimate of river fragmentation in Europe based on empirical and modelled barrier densities.

We assembled 629,955 unique barrier records from 36 European countries and surveyed 2,715 km of 147 rivers to ground truth barrier densities. We also modelled the location and number of missing barriers.

As there is no agreed definition, we defined artificial instream ‘barrier’ as “any built structure that interrupts or modifies the flow of water, the transport of sediments, or the movement of organisms and can cause longitudinal discontinuity”. We classify barriers into six funcional types (Figure 1).

BARRIER FUNCTIONAL TYPES

Dam

A dam is a barrier that regulates the flow of water and raises the water level, forming a reservoir. Dams come in many shapes and sizes but water does not normally overflow the crest.

Dams are often used to generate hydropower or supply water for irrigation or drinking. They cause a significant alteration of river flow and disrupt the transport of sediments.

Dam (Dora Baltea river, Italy). S. Bizzi (2017

Weir

A weir is a barrier that raises the water level and regulates the water flow, but unlike a dam, water flows freely over its crest.

Many weirs are old and many may be abandoned, revealing their former use abstracting water for watermills, sawmills, and foundries. They often have heights less than 5 m.

Consolidation weir (Arno river, Italy. S. Bizzi (2017)

Sluice

A sluice is a barrier with one or more movable gates that are used to control water levels and flow rates. By opening or closing the sluice gate, water levels and flow rates can be altered.

Sluices are used in river locks and canals, to allow boats to navigate over dams or overcome sudden changes in channel slope. They allow canals to be built over uneven landscapes.

Tidal sluice gate (Netherlands). J. Van Deelen (2017)

Figure 1. The six functional types of longitudinal instream barriers (from Jones *et al*., 2020).

BARRIER FUNCTIONAL TYPES

Ramp

A ramp or bed-sill is a structure designed to stabilize the channel bed. They are usually built in high energy streams to reduce channel erosion caused by channel straightening. They often have a height of less than 1-2m

A) Bed sill (Marecchia river, Italy). B. Belletti (2017)
B) Rock ramp (Switzerland). R. Bösiger (2018

Ford

A ford is a low-head structure typically built in shallow streams for wading or crossing. Fords do not raise the water level or regulate the flow of water.

Ford (Orco river, Italy). M. Micotti (2017

Culvert

A culvert is a structure built to carry the stream flow at road crossings. They are typically built in small streams, under forest tracks or secondary roads. Unlike fords, culverts enclose the stream flow fully (pipe) or partially (half-pipe). They are often embedded in soil and may vary in shape from round and elliptical to box-shaped. Culverts do not raise the water level, but they can block the movement of organisms if they are perched, too shalow, or have too high water velocities.

Culvert (Afan river, United Kingdom). J Jones (2019)

Other

Other types of barriers that can impact on longitudinal connectivity include fish traps and lateral groynes or wing dykes built perpendicular to the river bank to divert the flow of water and reduce flooding or bank erosion, such as the one shown in the picture.

Other (Dora Baltea river, Italy). B. Belletti (2017)

MAIN FINDINGS

1 There are at least 1.2 million instream barriers in Europe (mean density = 0.74 barriers/km), 68% of which are low-head (<2m) structures such as culverts, ramps and fords (Table 1, Figure 1).

Table 1. Number of unique barrier records (excluding duplicates) in the AMBER Barrier Atlas and corrected barrier estimates obtained by applying national correction factors on the level of underreporting derived from field surveys (Belletti *et al*., 2020)

Country	ECRINS river network	Number of each barrier type									Atlas barrier density	Corr. barrier density	Corr.
	(km)	dam	weir	sluice	culvert	ford	ramp	other	unknown	total	(No km^{-1})	(No km^{-1})	No. barriers
Albania (AL)	16,717	210							308	518	0.03	0.51	8,607
Andorra (AD)	273	43	267							310	1.14	1.49	407
Austria (AT)	41,429	19,379	2,208		4		5	5,811		27,407	0.66	1.04	43,189
Belgium (BE)	8018	1504	1388	254	1993		4	1394	205	6742	0.84	1.19	9580
Bosnia-Herzegovina (BA)	25,295	20	1					11	182	214	0.01	0.2	5,150
Bulgaria (BG)	42050	187							549	736	0.02	0.42	17800
Croatia (HR)	21,985	25							88	113	0.01	0.04	889
Cyprus (CY)	2811	119		1				165		285	0.1	0.46	1280
Czech Republic (CZ)	26,788	2,210	1,934				7	1,331		5,482	0.2	0.78	20,846
Denmark (DK)	6723	333	380	19	186		863	305	980	3066	0.46	0.62	4176
Estonia (EE)	9,981	187								187	0.02	0.8	7,939
Finland (FI)	87703	96						733		829	0.01	0.36	31876
France (FR)	183,373	8,744	36,855	346	5915	357	4512	1,579	3652	61,960	0.34	0.35	63,932
Germany (DE)	104142	4250	19236	530	72795	337	76895	4944	9	178996	1.72	2.16	224658
Greece (GR)	61,994	143							75	218	0	0.36	22,508
Hungary (HU)	21483	781	1048	875				79		2783	0.13	0.15	3124
Iceland (IS)	16,367	32								32	0	0.36	5,826
Ireland (IE)	19503	32	389	30	390	34	554	87	16	1532	0.08	0.43	8436
Italy (IT)	134,868	1,406	20,428		5	586	7849	1,760	5	32,039	0.24	0.49	65,756
Latvia (LV)	16589	601							1	602	0.04	0.39	6474
Lithuania (LT)	17,218	125							1132	1,257	0.07	0.45	7,800
Luxembourg (LU)	960	6	7		3		15	5		36	0.04	0.39	376
Montenegro (ME)	7,621	5							33	38	0	0	38
Netherlands (NL)	3220	15	55762	328	11		30	6440		62586	19.44	19.44	62610
North Macedonia (MK)	12,876	7							166	173	0.01	0.37	4,731
Norway (NO)	107079	3977	1		1		1			3980	0.04	0.08	9045
Poland (PL)	80,401	1,071	10,742	2707	1339		44		268	16,171	0.2	0.96	77,530
Portugal (PT)	31451	725	117				1		354	1197	0.04	0.51	16095
Romania (RO)	78,829	305	6	3				302	175	791	0.01	0.23	18,095
Serbia (RS)	25376	73	3						197	273	0.01	0.59	14901
Slovakia (SK)	20,412	147	4					1		152	0.01	0.36	7,378
Slovenia (SI)	9891	23	1						669	693	0.07	0.13	1321
Spain (ES)	187,809	5,131	17,005	10	135	104	2725	1,429	3343	29,882	0.16	0.91	171,203
Sweden (SE)	128357	7628	2483		8013		1033		338	19495	0.15	0.24	31068
Switzerland (CH)	21,178	415	4,599	93	19888	722	103961	670	15113	145,461	6.87	8.11	171,693
United Kingdom (UK)	68719	1566	17539	2915	266	61	92	1280		23719	0.35	0.7	48293
Total	**1,649,489**	**61,521**	**192,403**	**8,111**	**110,944**	**2,201**	**198,591**	**28,326**	**27,858**	**629,955**	**0.38**	**0.74**	**1,213,874**
												Sum	**1,194,629**

MAIN FINDINGS
(cont.)

2 The distribution of barriers (Figure 2) largely mirrors the distribution of other anthropic pressures in Europe's rivers, like river-road crossing (Figure 3).

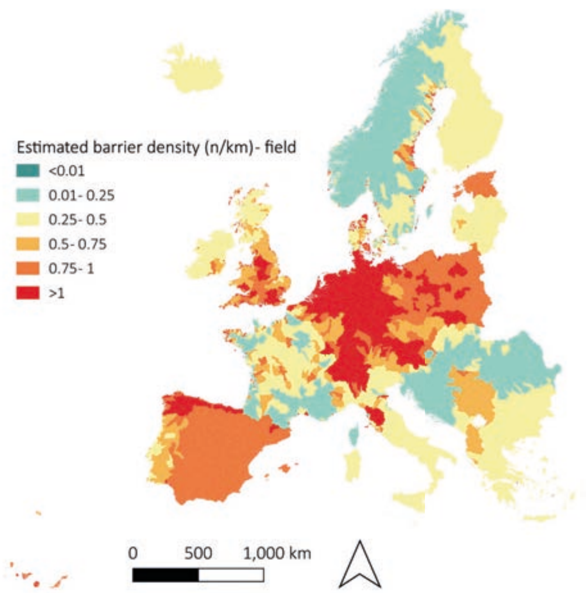


Figure 2. Estimates of barrier density (No./km) across Europe based on ground-truthed barrier numbers (Belletti *et al.*, 2020)

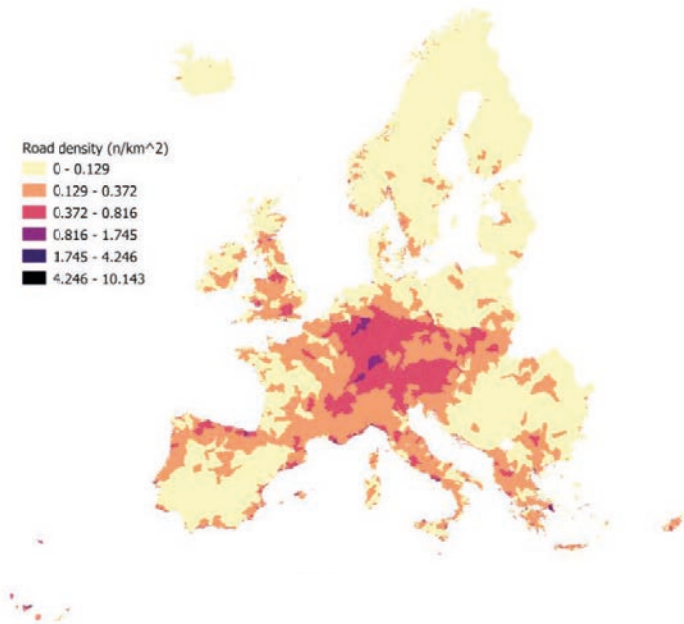


Figure 3. Density of river-road crossings (Belletti *et al.*, 2020).

MAIN FINDINGS
(cont.)

3 Barrier density can be predicted by agricultural pressure, road density, extent of surface water, and elevation.

4 Existing barrier records underestimate true barrier numbers by ~61% but this varies considerably between countries. Some countries like the Netherlands, France and Switzerland have accurate barrier records with little under-reporting, but others like Sweden, Albania, Greece and Romania tend to record only large structures which underestimate the true extent of river fragmentation (Figure 3).

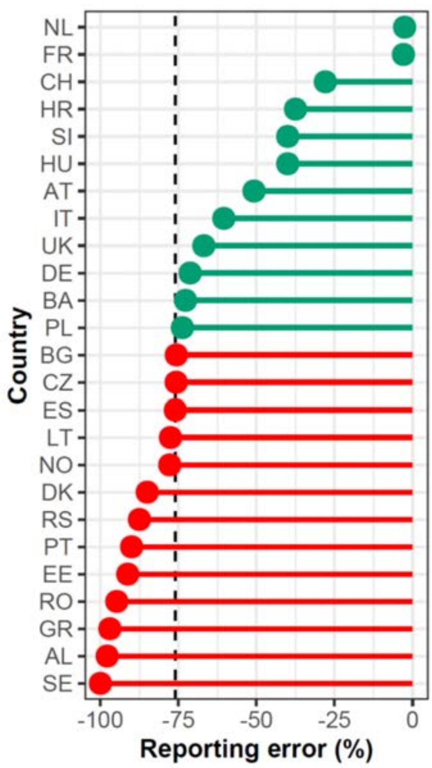
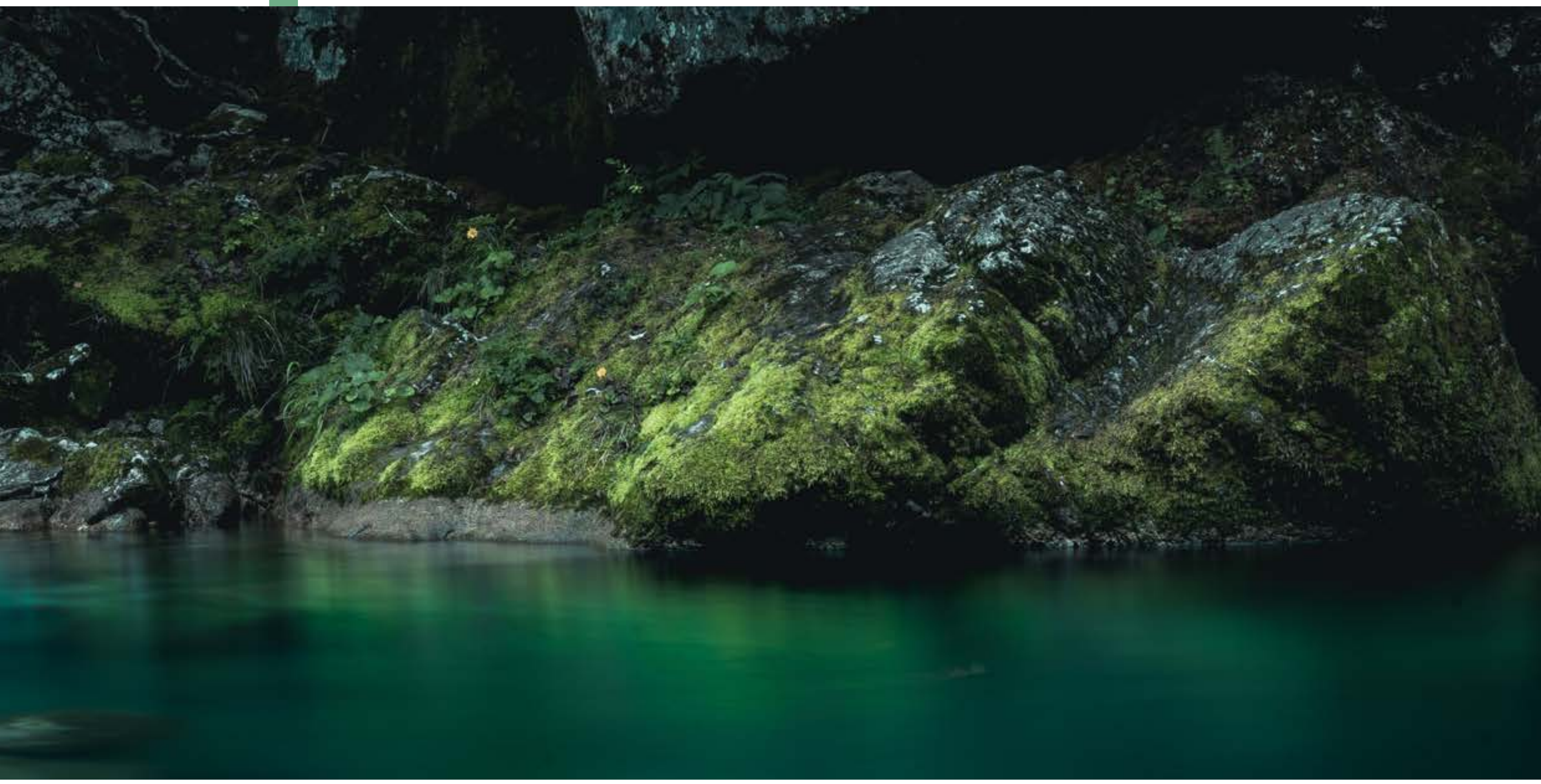


Figure 4. Barrier under-reporting error obtained by comparing barrier records in the existing databases (the AMBER Barrier Atlas) and those derived from field surveys. Values are colour-coded depending on the whether they are above (red) or below (green) the median barrier error across countries (dotted line). Country codes are given in Table 1 (Belletti *et al*., 2020)

MAIN FINDINGS
(cont.)

5 All rivers we surveyed in Europe have barriers but relatively unfragmented rivers are still found in the Balkans, Scandinavia, the Baltic states, and parts of southern Europe.

6 Many of the barriers we surveyed are no longer in use, may pose a flood hazard and should be removed.



Soča Valley, Slovenia, image by Christian Werther

POLICY IMPLICATIONS & RECOMMENDATIONS

The new EU Biodiversity Strategy aims to reconnect at least 25,000 km of Europe's rivers by 2030. To achieve this we make the following recommendations:

1	AMBER has produced the first harmonised pan-Europen Atlas of instream barriers but this is incomplete and needs to be kept updated. Member States need to complement it and keep it updated under the auspices of the EC. The Atlas is not static, new barriers are being built while others are removed or are washed away. So it is important to have procedures in place to keep records updated.
2	Better mapping and monitoring of barrier numbers is needed, particularly of low head structures, as these are the most abundant and the main cause of fragmentation.
3	To fill barrier data gaps we emphasize the value of ground truthing via river suveys, and the contribution that citizen scientists can make for validating and augmenting barrier numbers and locations.
4	The existing ECRINS river network undestimates river length and is generally too coarse for detailed barrier mitigation planning. We call for the development of a more detailed pan-European hydrographic map to support the restoration of connectivity.
5	Information is needed on the current use and legal status of all barriers, as many are out of use and could be removed.
6	To restore connectivity, current rates of fragmentation need to be halted, and this may require a critical reappraisal of building new dams against the alternative of enhancing the efficiency of existing ones, and other alternative sources of energy and water storage.

TAKE HOME MESSAGE

Views on global patterns of river fragmentation have been dominated by consideration of fish needs and large dams only but our study shows that most barriers to free-flow are small structures that are difficult to detect and are poorly mapped.

Loss of connectivity depends mostly on the number and location of barriers, not on their height.

Many barriers in Europe are old and obsolete, and provide unprecedented opportunities for restoring connectivity.

Relatively unfragmented rivers exist but require urgent protection from new dam developments.

References

Belletti, B., C. Garcia de Leaniz, J. Jones, S. Bizzi, L. Börger, G. Segura, A. Castelletti, W. van de Bund, K. Aarestrup, J. Barry, K. Belka, A. Berkhuysen, K. Birnie-Gauvin, M. Bussettini, M. Carolli, S. Consuegra, E. Dopico, T. Feierfeil, S. Fernández, P. Fernandez Garrido, E. Garcia-Vazquez, S. Garrido, G. Giannico, P. Gough, N. Jepsen, P. E. Jones, P. Kemp, J. Kerr, J. King, M. Łapińska, G. Lázaro, M. C. Lucas, L. Marcello, P. Martin, P. McGinnity, J. O'Hanley, R. Olivo del Amo, P. Parasiewicz, G. Rincon, C. Rodriguez, J. Royte, C. T. Schneider, J. S. Tummers, S. Vallesi, A. Vowles, E. Verspoor, H. Wanningen, K. M. Wantzen, L. Wildman, and M. Zalewski. 2020. Broken rivers: ground-truthing the world's most fragmented rivers. Authorea (pre-print) doi: 10.22541/au.159355955.53596231.

Jones, J., B. Belletti, L. Börger, G. Segura, S. Bizzi, W. Van de Bund, and C. Garcia de Leaniz. (2020). Quantifying river fragmentation from local to continental scales: data management and modelling methods. Authorea (pre-print) doi: 10.22541/au.159612917.72148332.

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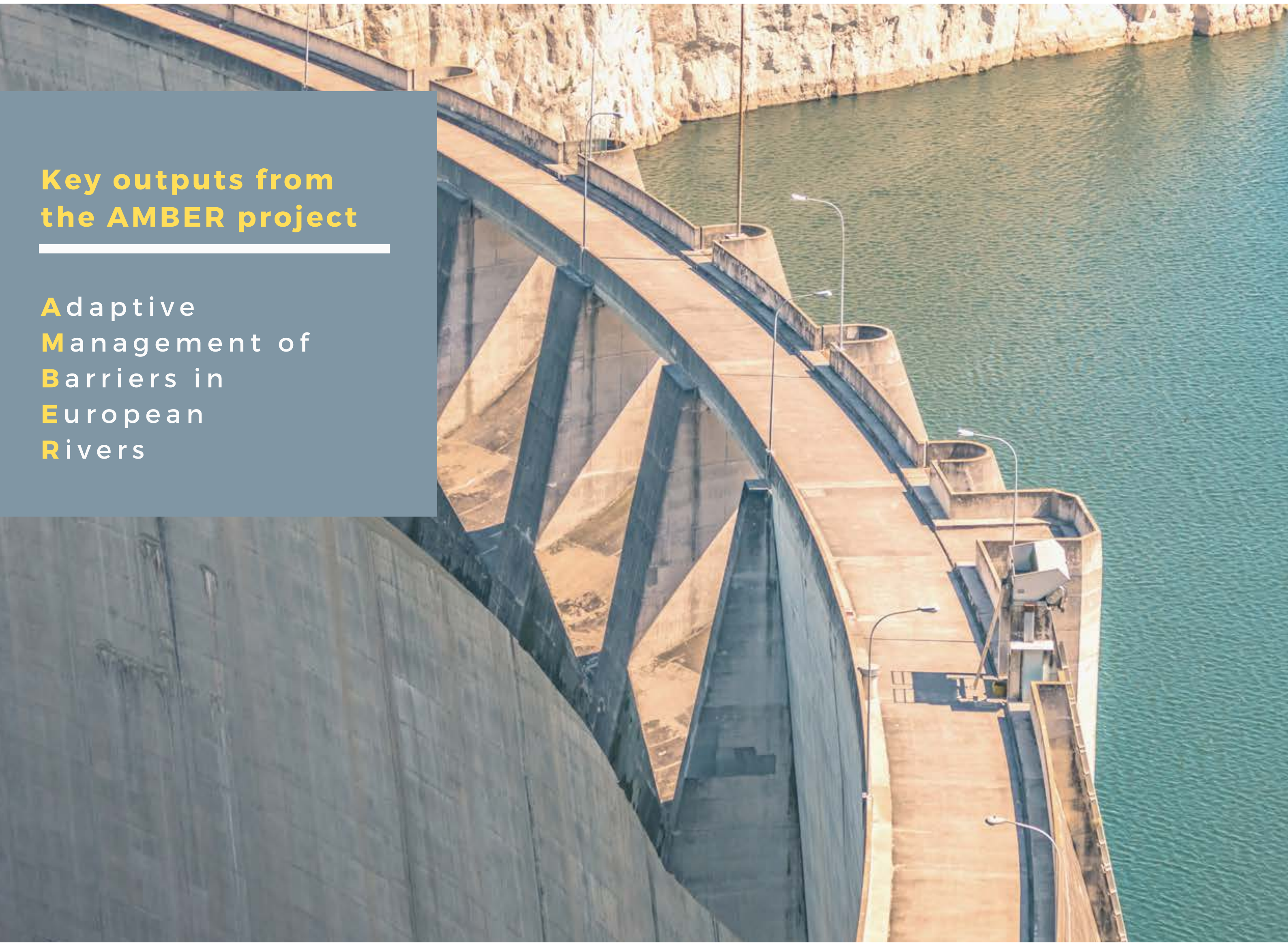
AMBER POLICY BRIEF 2



Key outputs from the AMBER project

Adaptive
Management of
Barriers in
European
Rivers

TOOLS FOR MANAGING AND RESTORING CONNECTIVITY IN EUROPEAN RIVERS

This policy brief outlines the tools developed in WP2 and WP3 as part of the H2020 AMBER project

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This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 689682

https://amber.international/

1. OVERVIEW OF AMBER TOOLS

This policy brief outlines some of the tools developed during the AMBER project to help resource managers quantify stream fragmentation, assess barrier impacts and benefits, and make better, informed decisions on existing and future barriers based on what if scenarios. Three types of tools were developed, depending on the problems they help to solve:

1. Data Acquisition Tools (DATs)
To collect and harmonize data, to fill gaps, and to make sense of disparate information

2. Mapping & Assessment Tools (MATs)
To assess barrier effects, to predict changes, and to turn information into knowledge

3. Decision Support Tool (DSTs)
To consider trade-offs, to inform decisions, and to turn knowledge into application based on *what if* scenarios

DAT1. BARRIER TRACKER APP

Author or Developer: Natural Apptitude for the AMBER consortium
Text: Carlos Garcia de Leaniz

The AMBER Barrier Tracker (Figure 1) is a smartphone app that enables users to locate barriers in the field, take a photograph and upload it into the cloud where it can be used to build a better map of stream fragmentation.

Figure 1. The Barrier Tracker app for recording barriers and filling data gaps developed as part of the AMBER citizen science programme in Europe https://portal.amber.international/.

Problems or needs addressed by this tool

Most barriers are grossly underreported in existing databases, as these tend to report medium to large size dams only. The Barrier Tracker harnesses the power of citizen science to provide a more complete picture of barrier abundance. It enables users to locate all types of barriers (classified into 6 main types), assess their main features, including height, current use and conservation status. The latter information is essential for identifying obsolete barriers and prioritize efforts for mitigation or removal.

References

Olivo, R. (2020). Let it Flow Magazine. https://amber.international/wp-content/uploads/2020/07/AMBER-magazine-Digital.pdf
page 30
AMBER deliverable url link:
https://amber.international/deliverables-2/

Source & availability

Available in 12 languages

Danish	German	Slovenian
Dutch	Italian	Spanish,
English	Polish	Ukrainian
French	Portuguese	Welsh

The app is free to use and download. It has no adverts. It is available for Android and IoS:

Download on the App Store · GET IT ON Google Play · AMBER

Examples of Use

Various videos have been made to demonstrate the use of the barrier tracker

- English
- Lithuanian
- Spanish

Updates

Requires Android 4.4 and higher
Requires iOS 9.0 or later. Compatible with iPhone, iPad and iPod touch.
Version 1.1.0 (15 March 2019)
Available in two new languages (Ukrainian and Slovenian) New translations added for all languages for updated functionality Export personal barrier records from app to email account via Account page Improvements made to mapping
New map data added
Various small amendments and bug fixes
Version 1.1.1 (27 February 2020)
Available for downloading all over the world
Version 1.1.2 (28 September 2020)
Essential Coreo and OS update
New translations added for updated functionality
Various small amendments and bug fixes

DAT2. GROUND TRUTHING OF STREAM BARRIERS

Author or developer: Jones, J., Belletti, B, Börger., L. Segura, G., Bizzi, van de Bund, W., Garcia de Leaniz, C.
Text: Carlos Garcia de Leaniz

This tool enables users to account for underreported barriers in existing databases and derive correction factors to get more accurate estimates of the abundance, location and type of barriers. A sampling strategy is developed to obtain *in-situ* information on barriers using the Barrier Tracker (Tool DAT1).

Problems or needs addressed by this tool

Existing barrier inventories are seldom complete and cannot easily be compared as they were built for different purposes, may record only a subset of barriers types, and differ also in spatial resolution, coverage, and accuracy. This tool makes use of standardised field surveys (i.e. river walkovers) to derive correction factors to obtain more precise estimates of barrier density via bootstrapping. This information is required to derive more realistic estimates of barrier density and hence of river fragmentation.

Training needs

Users must follow a standardised sampling protocol (detailed in Belletti et al., 2020; Jones et al., 2020) and agree on a common definition of barriers types, as shown below (Figure 2).

Examples of Use

Examples of use are given in Belletti et al. (2020) and Jones et al (2019, 2020).

References

- AMBER deliverable url link: https://amber.international/deliverables-2/
- Belletti, B., et al. (2020). Broken rivers: ground-truthing the world's most fragmented rivers. Authorea (pre-print) doi: 10.22541/au.159355955.53596231
- Jones, J. et al. (2019). A comprehensive assessment of stream fragmentation in Great Britain. Sci. Tot. Env. 673, 756-762 (2019).
- Jones, J., et al. (2020). Quantifying river fragmentation from local to continental scales: data management and modelling methods. Authorea (pre-print) doi: 10.22541/au.159612917.72148332.

Source & availability

The tool is fully described in AMBER deliverable D1.3, available at the AMBER website https://amber.international/. It is also described in Jones et al. (2019, 2020) and Belletti et al. (2020).

Improvements over state of the art

Most previous attempts to harmonise existing barrier databases have taken a common denominator approach and used only information from large dams that can sometimes be detected via remote sensing (e.g. Grill et al., 2019). The merits of *in situ* barrier ground truthing first proposed by AMBER (Jones et al., 2019) have recently been demonstrated (Atkinson et al., 2020; Sun et al., 2020).

Updates

NA

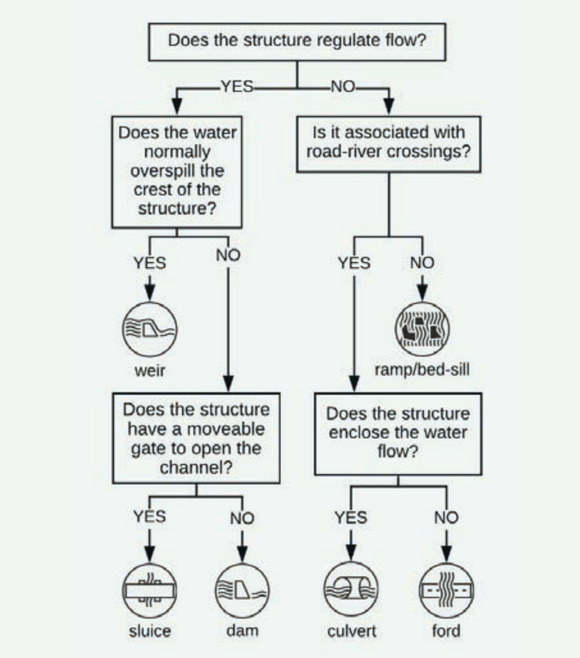


Figure 2. Decision tree used for classifying longitudinal stream barriers into six main functional types. Structures that do not meet these criteria are classified as "other" (from Jones et al., 2020).

DAT3. BARRIER DUPLICATE EXCLUDER

Author or developer: Jones, J., Belletti, B, Börger., L. Segura, G., Bizzi, van de Bund, W., Garcia de Leaniz, C.
Text: Carlos Garcia de Leaniz

This tool enables users to detect and exclude duplicates from barrier databases and get more accurate estimates of true barrier density.

Problems or needs addressed by this tool

Duplicate records are common in existing barrier inventories whenever more than one barrier database are merged. This introduces an upward bias in estimates of barrier density.

Training needs

No special training needs are required but the following workflow has been successfully used in AMBER (Figure 3).

Examples of use

See Jones et al. (2020)

Updates

NA

References

- AMBER deliverable url: link: https://amber.international/deliverables-2/
- Jones, J. et al. (2019). A comprehensive assessment of stream fragmentation in Great Britain. Sci. Tot. Env. 673, 756-762 (2019).
- Jones, J., et al. (2020). Quantifying river fragmentation from local to continental scales: data management and modelling methods. Authorea (pre-print) doi: 10.22541/au.159612917.72148332.

Source & availability

The tool is fully described in AMBER deliverable D1.3, available at the AMBER website https://amber.international/

It is also described in Jones et al. (2019, 2020) and Belletti et al (2020).

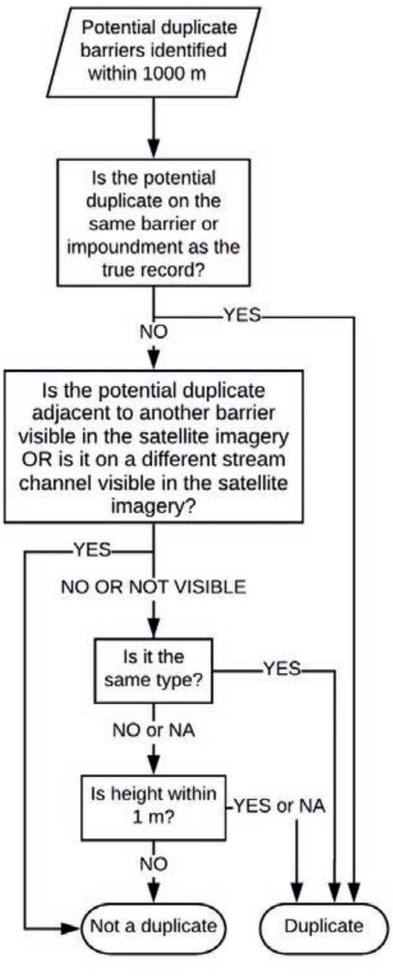


Figure 3. Decision tree used to identify duplicate barrier records (from Jones et al., 2020).

MAT1. RAPID BARRIER ASSESSMENT TOOL

Author or developer: Jim Kerr, Andrew Vowles, Paul Kemp
Text: Jim Kerr

The Rapid Barrier Assessment Tool automates the process of calculating barrier passability scores for multiple fish species based on barrier height, slope and depth. The tool is based on the French ICE (Informations sur la Continuité Ecologique) protocol (Baudoin et al., 2014) and produces barrier passability scores ranging from 0 – 1: 0 (total barrier), 0.33 (high-impact partial barrier), 0.66 (medium impact partial barrier), 1 (low-impact passable barrier). The tool also estimates the hydropower potential (Watts) at the site through a simple assessment of discharge and head drop.

Problems or needs addressed by this tool

Telemetry and other empirical studies provide valuable information on barrier passability, but they are generally very resource intensive and tend to focus on salmonids and/or large barriers. The Rapid Barrier Assessment Tool provides approximate passability scores quickly and effectively to facilitate prioritisation of restoration actions at various spatial scales.

Training needs

The tool is very simple to use and does not require any specific training. It is supplied with a guide to help users install the software and includes step-by-step instructions of how to assess a barrier and produce passability scores.

Updates

NA

Source & availability

The tool can be downloaded from the AMBER website, AMBER deliverable 2.3
https://amber.international/software/

It is currently available in English only.

Examples of use

We have critically reviewed and tested current methods of barrier impact assessments in the EU and elsewhere
https://www.youtube.com/watch?v=419s98rvTIs.

The tool has been used to produce passability scores for hundreds of barriers in Ireland and England.

Barrier Assessment Protocols

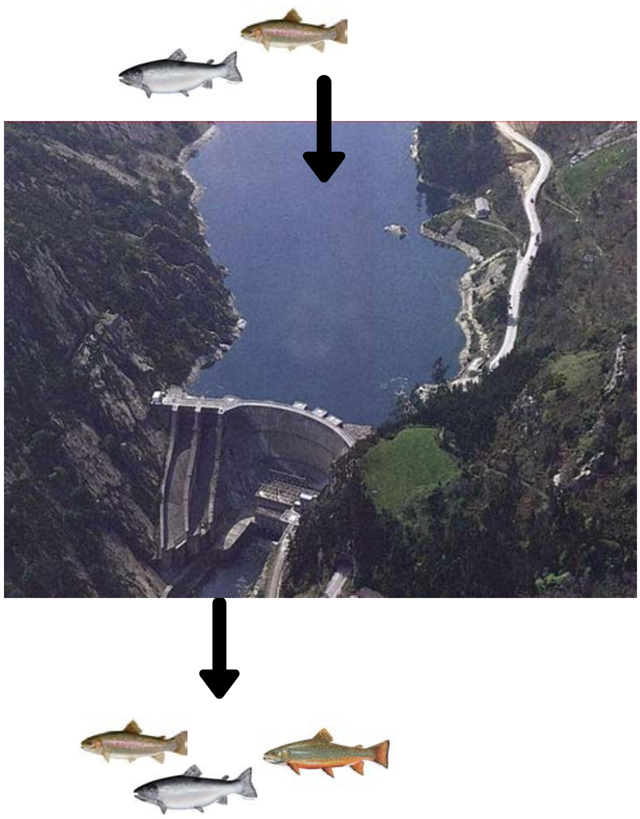
References

Baudoin, J-M., Burgun, V., Chanseau, M., Larinier, M., Ovidio, M., Sremski, W., Steinbach, P. and Voegtle, B. (2014). The ICE protocol for ecological continuity. Assessing the passage of obstacles by fish. Concepts, design and application. The National Agency for Water and Aquatic Environments (ONEMA). 200 pp. ISBN: 979-10-91047-29-6.

MAT2. eDNA TOOL KIT

Author or Developer: Laura Clusa, Sara Fernández, Eva García-Vázquez, Deiene Rodriguez-Barreto, Richard O'Rorke, Chloe Robinson, Sofia Consuegra
Text: Carlos Garcia de Leaniz

The eDNA Toolkit enables users to detect longitudinal discontinuities in river fauna and flora caused by barriers (Figure 4).



Source & availability

The toolkit is described in AMBER deliverable 2.5 on the AMBER website: https://amber.international/deliverables-2/

It is also described in Clusa et al. (2017a,b), Fernandez et al. (2018), and Robinson et al. (2019a,b).

Figure 4. Example of application of eDNA to the assessment of the impact of five dams (D1-D5) on the distribution of salmonid fish in the River Nalón, Spain (adapted from Clusa et al., 2017a).

Problems or needs addressed by this tool

The eDNA assays developed in AMBER allow users to infer presence/absence data for several targeted species from small water samples. Community-wide and species-specific markers were developed for the detection of native and invasive aquatic species using Next Generation Sequencing (metabarcoding) and real time PCR (qPCR).

Training needs

Standard Operational Procedures (SOPs) for collecting water samples are available from the AMBER Field Guide and Muha et al., 2019. Training in molecular techniques and appropriate equipment is required but a number of companies now offer eDNA analysis commercially.

MAT2. eDNA TOOL KIT

Author or Developer: Laura Clusa, Sara Fernández, Eva García-Vázquez, Deiene Rodriguez-Barreto, Richard O'Rorke, Chloe Robinson, Sofia Consuegra
Text: Carlos Garcia de Leaniz

Examples of use

The eDNA toolkit has been used to examine barrier effects in relation to Aquatic Invasive Species (AIS) in the Iberian Peninsula (Clusa et al., 2017a,b, Fernandez et al.,2018) and in Great Britain (Robinson et al, 2019a,b) and also in relation to fish community composition in the rivers Nalón and Guadalhorce (Spain), rivers Garry, Afan and Tawe (UK), and river Allier in France (Deliverable D2.5).

Studies have shown that sensitivity increases with volume of water and number of replicates. It is recommended that 1L is collected at each site in six independent replicates (i.e. 6L of water per site). This can be filtered on site with the help of 50 ml syringe and a filter capsule or brought to the laboratory (SOP in AMBER Field Guide).

Updates
NA

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MAT3. FISH HABITAT MODELLING AND MAPPING (MesoHABSIM)

Author or Developer: Piotr Parasiewicz, Katarzyna Suska, Janusz Ligięza, & Rushing Rivers Institute
Text: Piotr Parasiewicz

This tool enables users to assess the amount of habitat suitable for the fish community up and downstream of a barrier using the MesoHABSIM methodology (Figure 5). The accompanying SimStream software helps predict the impact of different fish habitat management scenarios under climate change.

Source & availability

The tool is fully described in AMBER deliverable D2.6, available at the AMBER website https://portal.amber.international/ and at MesoHABSIM.org

Problems or needs addressed by this tool

Barriers impact on fish communities not only by impeding fish movements, but also by altering fish habitat upstream and downstream of the barrier. The MesoHABSIM tool allows users to predict the effects of barrier construction and barrier removal on fish habitat under different scenarios.

Updates

NA

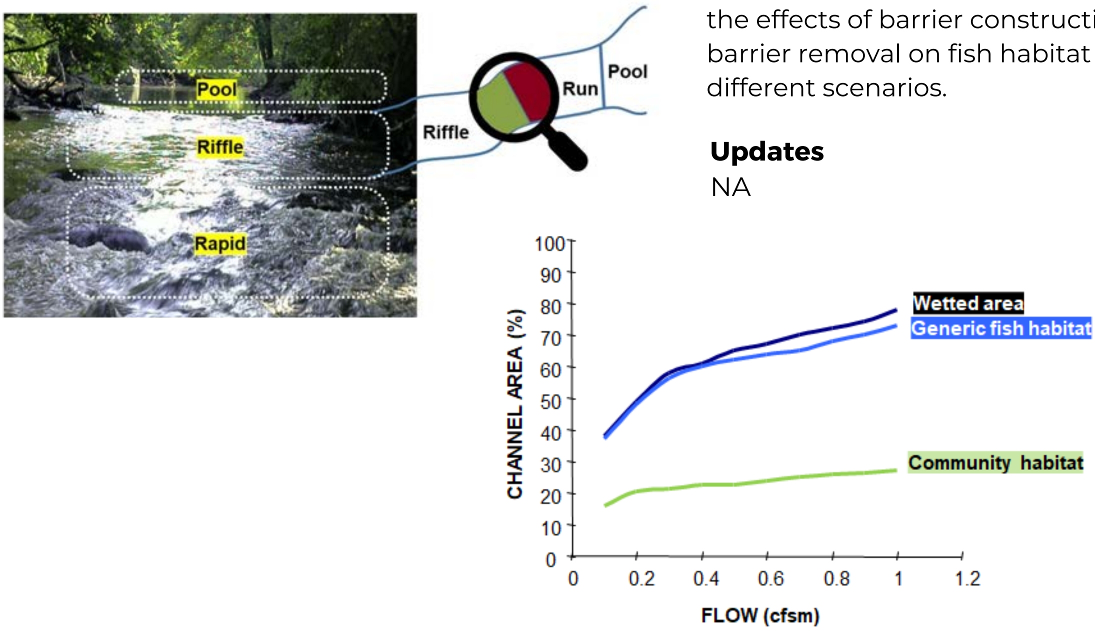

Figure 5. Schematics of the MesoHABSIM method. The distribution of hydromorphic units is mapped in the river (upper left), suitability filters are developed from fish observations to distinguish suitable (green) and non suitable (red) habitat areas (upper right). Suitable proportions of channel area observed at number of flows are expressed as rating curves. Generic fish habitat is suitable area available for all fish. Community habitat curves represent suitable area weighted by expected species ratio in the community. Rating curve of wetted area demonstrates proportion of entire (suitable and unsuitable) area available (bottom panel).

Training needs

Training on the use of this tool is available in the form of a video-course, tutorials and manuals at MesoHABSIM.org.

Examples of use

Examples of use are described in Deliverable D4.2 and at http://mesohabsim.org/

References

Let it Flow Magazine https://amber.international/wp-content/uploads/2020/07/AMBER-magazine-Digital.pdf Page 13
Deliverable D4.2 https://amber.international/deliverables-2/

DST1. RIVER INFRASTRUCTURE PLANNING TOOL (RIP)

Author or Developer: Jesse O'Hanley, Tim Feierfeil, Klemens Kauppert
Text: Jesse O'Hanley

The AMBER River Infrastructure Planning (RIP) helps environmental planners and river managers balance environmental and socioeconomic trade-offs associated with river infrastructure by selecting the best combination of barrier removal, construction and mitigation actions. The tool considers four Key Performance Indicators: (1) longitudinal connectivity, (2) project implementation costs, (3) hydropower generation potential, and (4) water storage capacity. It has an easy-to-use Microsoft Excel based graphical user interface for data input and result generation (Figure 6).

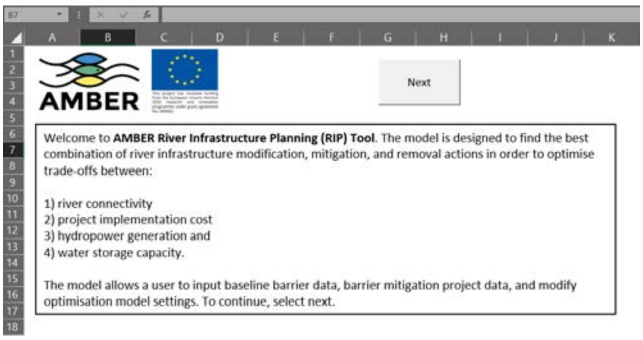

Figure 6. Screens-shot of the Microsoft Excel based graphical user interface for the AMBER River Infrastructure Planning (RIP) tool

Training needs

No specific training is required. Data formatting guidelines and help support prompts are integrated into the tool.

Source & availability

The simpler, Excel based version of the RIP tool can be downloaded from the AMBER website https://amber.international/software/

It is currently available in English only. Users need to download and install SolverStudio first before running AMBER RIP https://solverstudio.org/

Problems or needs addressed by this tool

Determination of how best to manage river infrastructure in the context of river connectivity restoration not only requires consideration of the interactive effects of barrier removal, construction and mitigation actions on river connectivity as well as assessment of multiple, potentially competing environmental and socioeconomic benefits and costs derived from river infrastructure. The AMBER RIP tool addresses this need through the development and application of advanced mathematical optimisation techniques to systematically target barrier removal, construction and mitigation in order to find the most efficient balance between competing goals.

DST1. RIVER INFRASTRUCTURE PLANNING TOOL (RIP)

Author or Developer: Jesse O'Hanley, Tim Feierfeil, Klemens Kauppert
Text: Jesse O'Hanley

Examples of use

The applicability of an advanced version of this has been tried in the River Neckar catchment (Germany; Figure 7) where there are more than 1,000 river barriers. Hydropower and shipping are two of the main human uses and were selected as the primary socioeconomic KPIs. The planning tool was tested across ten scenarios for adaptive barrier management, including the current situation and 9 possible future development scenarios.

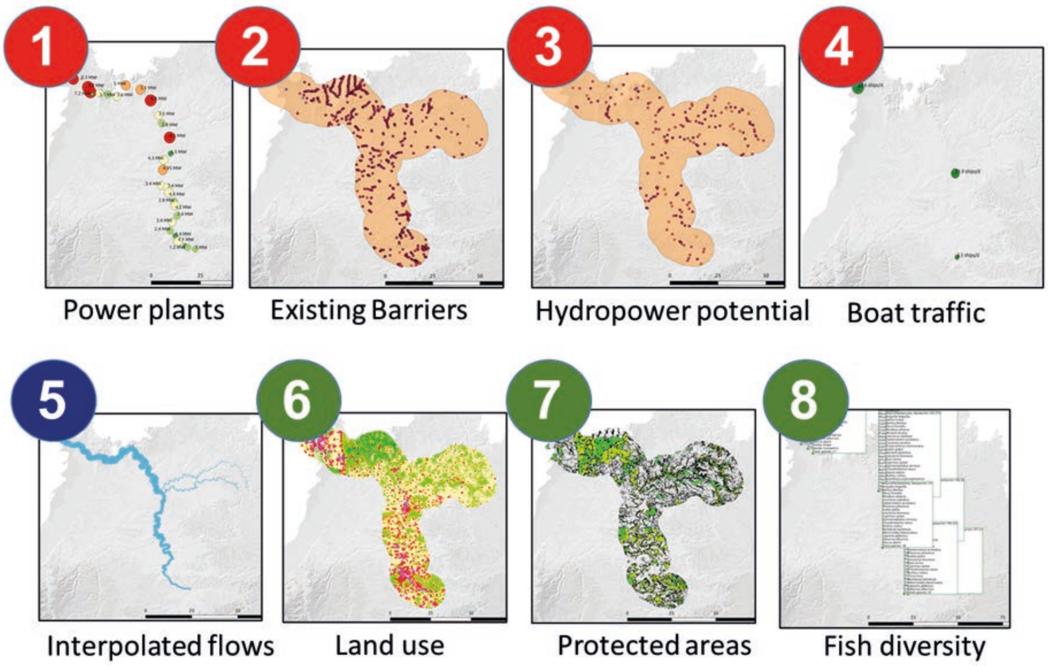

Figure 7. Some of the competing goals and constraints considered by the AMBER RIP tool to manage barriers in the Neckar catchment (Germany).

Updates

v 1.0 September 2020

References

Let it Flow Magazine. https://amber.international/wp-content/uploads/2020/07/AMBER-magazine-Digital.pdf page 59
AMBER deliverable link: https://amber.international/deliverables-2/

2. CRITICAL GAPS IN KNOWLEDGE & FEEDBACK FROM RIVER MANAGERS & ECOSTAT

On 11th March 2020 AMBER organised a webinar with the ECOSTAT group on Tools for Restoring Connectivity to inform this Policy Brief. We collected information via a questionnaire on the main challenges and critical gaps in knowledge for restoring river connectivity. The questionnaire consisted of three open-ended questions:

Q1 What are the main challenges for quantifying river connectivity?

Q2 What are the main challenges for assessing impacts of fragmentation?

Q3 What are the main challenges for restoring connectivity?

Responses were collected from 92 respondents from three stakeholder groups: EU River Basin Managers from 14 EU countries (n = 54), AMBER partners (n = 19) and participants from the ECOSTAT group (n = 19). Although some differences were found between stakeholder groups these are small and responses have been aggregated for analysis below.

Q1. What are the main challenges for quantifying river connectivity?

Most participants highlighted the lack of a comprehensive barrier database (29%), lack of sufficient resources (15%), and methodological challenges (15%) as the main practical impediments for quantify river connectivity (Figure 8).

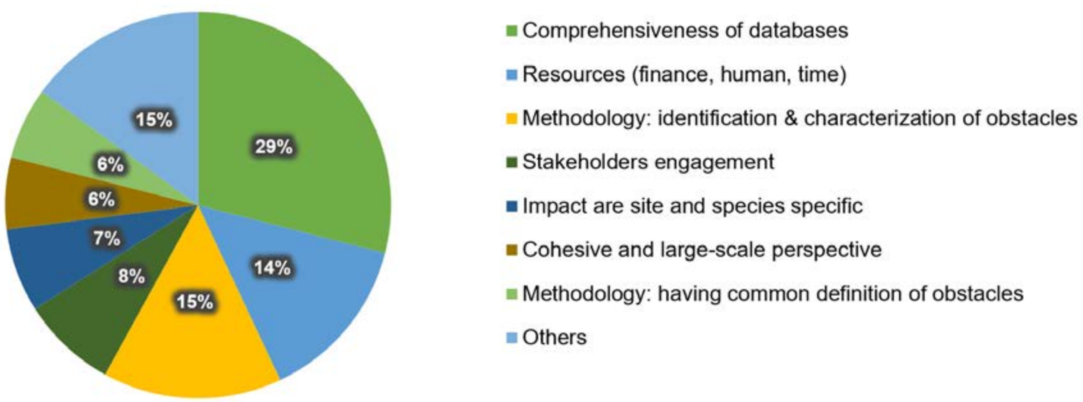

Figure 8. Main practical impediments for quantifying river connectivity.

Q2. What are the main challenges for assessing impacts of fragmentation?

Most participants highlighted the lack of data (21%), limited ecological understanding of barrier impacts (18%), and lack of resources (16%) as the main practical impediments for quantifying the impacts of river fragmentation (Figure 9).

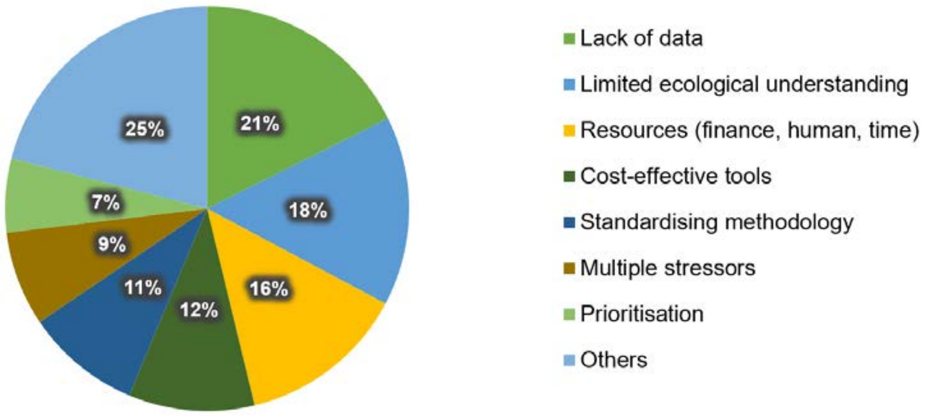

Figure 9. Main practical impediments for assessing the impact of river fragmentation.

Q3. What are the main challenges for restoring connectivity?

Most participants highlighted the lack of resources (40%) and involvement of stakeholders (39%) as the main practical impediments for restoring river connectivity (Figure 10).

Figure 10. Main practical impediments for restoring connectivity.

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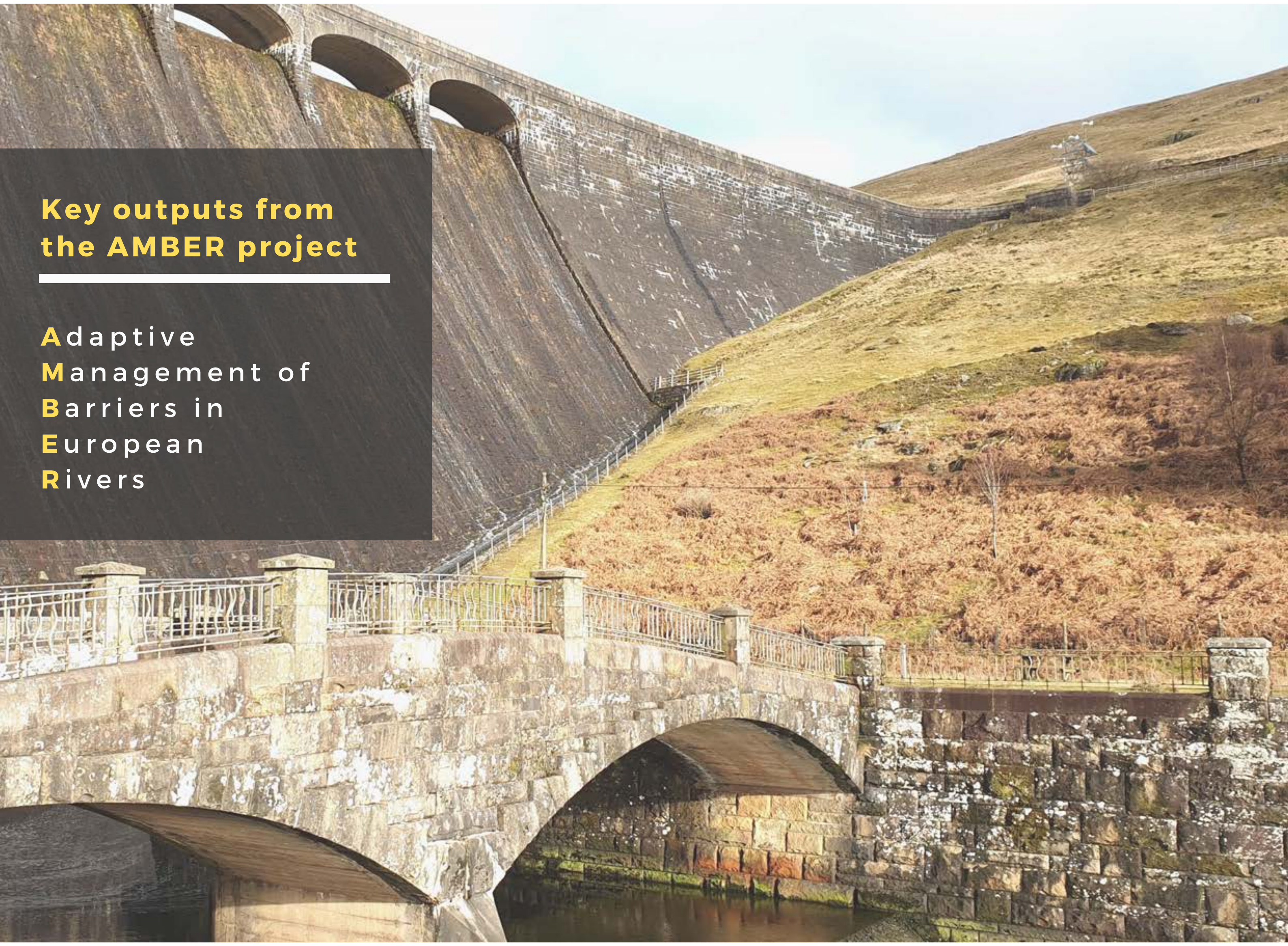
AMBER POLICY BRIEF 3



Key outputs from the AMBER project

Adaptive
Management of
Barriers in
European
Rivers

IMPACTS OF BARRIERS ON BIODIVERSITY OF RUNNING WATERS

This policy brief summarises the main impacts of artificial instream barriers on the biodiversity of running waters, derived from work carried out in WP2 and WP3 as part of the H2020 AMBER project

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This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under grant agreement No. 689682

https://amber.international/

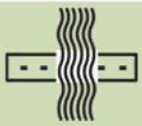
1. INTRODUCTION

The fragmentation of riverine habitats caused by barriers is one of the five main causes of biodiversity loss (Baudoin et al., 2014). Although barrier impacts are most obvious in the case of fish, it is important to also consider impacts on other biota to properly understand the impact of fragmentation on river biodiversity. ECOSTAT (2016) has stressed that fish should not be the only biological quality element used to assess Good Ecological Potential within the Water Framework Directive, even if barrier impacts on fish will usually be greatest.

Barrier impacts on river biota vary widely depending on species, habitats and barrier types, making global assessments difficult. For this reason AMBER developed a conceptual model that takes in account different river habitats and barrier types (Parasiewicz et al. 2018; Parasiewicz et al. 2019), and reviewed barrier impacts on different components of biodiversity (AMBER Deliverable 2.1., v2.0 https://amber.international/deliverables-2/).

Artificial barrier types can be grouped into six main functional types (Jones et al., 2020a), that differ in their impacts and call for different mitigating solutions (Table 1).

Table 1. The six functional types of longitudinal instream barriers identified in the AMBER project and potential solutions to reduce their impacts.

Barrier type	Description	Pictogram	Appropriate solutions
Dam	A barrier that blocks or constrains the flow of water and raises the water level resulting in permanent ponding		Side channels, engineered fish ways and nature-based solutions that ensure upstream and downstream passage over a wide range of flows and for the largest possible number of species, sizes, and life stages
Weir	A barrier that regulates the flow and water level where water flows freely over the crest		
Sluice	A movable barrier aimed at controlling water levels and flow rates in rivers and streams		Left open most of the time, so that it does not block fish movements
Culvert	A structure that carries the stream flow under an obstruction or river-road crossing		Connected to the river bed, it has a natural substrate, a low velocity and sufficient water depth to make it passable all year
Ford	A structure in a river or stream which creates a shallow place for crossing		There must be enough depth to guarantee fish passage all year
Ramp/ bed-sill	A structure designed to stabilize the channel bed and reduce bank erosion, recognizable by its stairway-like shape		There must be corridors between blocks to permit fish passage all year

2.BARRIER IMPACTS ON FISH

Recognising that there is substantial variation in barrier impacts is key for minimising the impacts of river fragmentation and also for designing more efficient fish passes, which are in many cases inefficient. Research on barrier impacts and fish passage has traditionally focussed on salmonids and other strong swimmers, largely ignoring other fish (Kemp, 2016). This partly reflects the common misconception that only migratory fish are affected by barriers (Birnie-Gauvin et al., 2018). However nearly all riverine fish undertake longitudinal movements along river networks to complete their life cycles and will be impacted by instream structures that impede their movements (Lucas et al., 1999).

European rivers can be classified into 15 different macro-habitat classes that differ in fish communities and in the predicted habitat alterations caused by barriers (Figure 1)

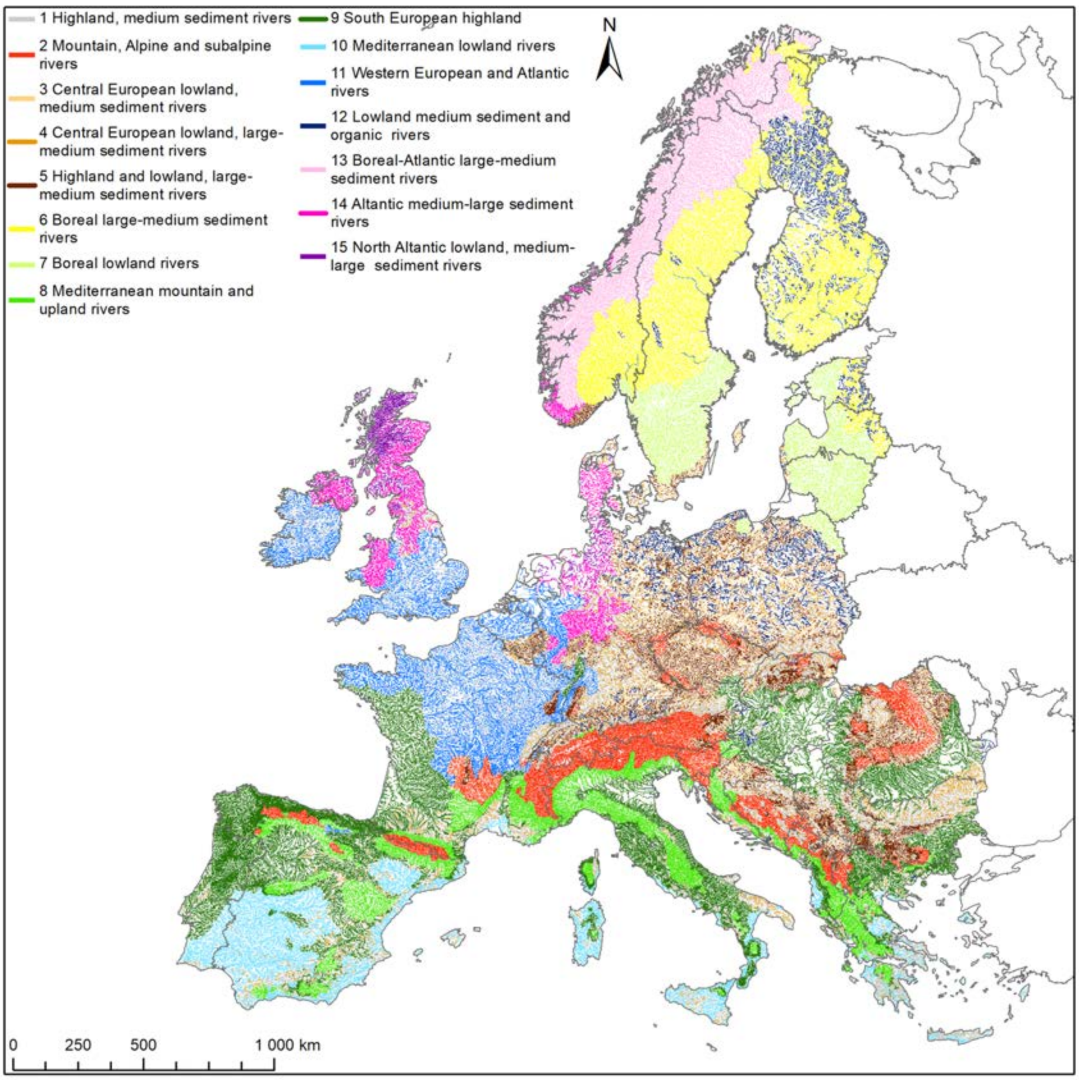


Figure 1. European rivers classified into 15 Macrohabitat types (AMBER D2.1, version 2.0).

The expected impact of different instream barriers on different fish macro-habitats are summarised in Table 2 in terms of loss of habitat.

Table 2. Predicted impact (penalized by loss of connectivity) of different instream barriers on the availability of 15 main fish macrohabitats present in European rivers red – severe habitat loss (>90%), orange – major habitat loss (50-89%), yellow – significant habitat loss (25-49%). AMBER Deliverable 2.2.

No.	Fish macro-habitat	Barrier type					
		Dam	Weir	Sluice	Culvert	Ford	Ramp
1	Highland, medium sediment						
2	Mountain, Alpine and subalpine						
3	Central European lowland, medium sediment						
4	Central European lowland, large-medium sediment						
5	Highland and lowland, large-medium sediment						
6	Boreal large-medium sediment						
7	Boreal lowland						
8	Mediterranean mountain and upland						
9	South European highland						
10	Mediterranean lowland						
11	Western European and Atlantic						
12	Lowland medium sediment and organic						
13	Boreal-Atlantic large-medium sediment						
14	Altantic medium-large sediment						
15	North Altantic lowland, medium-large sediment						

2.BARRIER IMPACTS ON FISH

2.1. DAMS AND WEIRS

Dams and large weirs (Figures 2-3) tend to impact fish and other biota to a greater extent than any other barrier as they affect both the habitat, the flow, and the movement of organisms. They can be particularly damaging on high energy rivers, where macro-habitats No. 2, 6, 7, and 13 are most common (Table 2), but also on lowland rivers where their effects can extend over longer distances (Birnie-Gauvin et al. 2017).

Figure 2. Examples of dams (photos: I.Wagner, ERCE; K. Suska, SSIFI, Poland).

Figure 3. Examples of overflowing weirs (photos: I.Wagner, ERCE; K. Suska, SSIFI, Poland).

2.BARRIER IMPACTS ON FISH

2.1. DAMS AND WEIRS

IMPACTS

CHANNEL BLOCKING

Channel blocking by dams and weirs can result in the extirpation of migratory fish if they are not able to reach the spawning areas, but also in a reduction in the abundance of freshwater resident fish which may not be able to complete their life cycle in parts of the river.

PONDING

Ponding caused by dams can shift fish communities as running waters are slowed down and converted into reservoirs. Ponding alters the macroinvertebrate communities and increases plankton abundance which favours the colonisation of planktivorous fish.

CHANGES IN CHANNEL MORPHOLOGY

Engineered structures associated with dams (like channels, dykes and levees) can cause the loss of floodplains and associated habitats (e.g. oxbow lakes) which can affect the growth and reproduction of obligate floodplain spawners, reducing fish diversity and overall productivity.

FLOW REGULATION AND CHANGES IN WATER VELOCITY

The operation of some dams alters the natural flow regime and this can disrupt the spawning of some fish, changing the fish community structure from seasonal spawners to more flexible species that are better able to cope with unnatural flows caused by flow regulation and hydro-peaking. Fish mortality can occur due to stranding after periods of extreme discharge. A frequent fluctuation of water velocity in the channelised reach downstream from the dam can alter fish communities due to the colonisation by resistant generalist species and loss of habitat for drifting larvae. The reproductive success of some species may decrease due to rapid flooding of nesting sites.

SILTING AND CHANGES IN WATER QUALITY

The growth of vegetation in the reservoir along with increase silting may cause a change in fish community structure. Increased erosion below the dam may also result in a reduction of non-visual predators. Substrate armouring and siltation can impact on benthic species and fish larvae. A shift in spawning time and reduction of reproductive success may occur due to increasing variation in water temperature. Thermal stratification in the reservoir may impair fish migrations, while oxygen starved waters may render the habitat unsuitable for many species. Fish mortalities may also occur in the reservoir due to water pollution and toxic algal blooms, especially in reservoirs with a high retention time. Flushing of anoxic waters, toxic sediments and hydrogen sulphide can reduce growth and cause fish mortalities downstream of the dam.

2.BARRIER IMPACTS ON FISH

2.1. DAMS AND WEIRS

OPERATIONAL IMPACTS

Turbines, screens and pumps can damage fish.

SOLUTIONS

The main mitigating solutions include:

REMOVAL OR PARTIAL BREACHING

This will typically be the preferred solution in the case of abandoned structures, whenever possible.

NATURE-TYPE FISHWAYS, SIDE CHANNELS, AND ENGINEERED FISH PASSES

These need to ensure that upstream and downstream passage is possible over a wide range of flows and for the largest possible number of species, fish sizes, and life stages.

RE-NATURALISATION AND COMPENSATION MEASURES DOWNSTREAM

Re-naturalisation of the channel downstream can increase habitat availability under modified flow conditions and support appropriate fish communities. The creation of spawning channels may offer some compensation for lack of access to spawning areas upstream.

OPERATIONAL MEASURES

Maintenance of appropriate environmental flows, coupled with a reduction in the frequency and magnitude of flush flows and an extension of peak rise times will help to support downstream fish communities.

2.2. SLUICE GATES

IMPACTS

Sluice gates (Figure 4) can block streams temporarily (but also permanently) and cause significant losses of fish habitat (Table 2). Rapid flow fluctuations may result in the drying up of fish habitat or the washing out of sensitive life stages downstream. Particularly damaging are the flow releases at navigation locks or the release of water at reservoirs during clean-up.

SOLUTIONS

With adequate management, the impact of sluices can be reduced, for example in some places sluice gates can be left open during critical times to avoid blocking fish migrations.

Figure 4. Examples of sluice gates (photos: Z. Kaczkowski (ERCE; Polish Waters Warsaw).

2.3. CULVERTS

IMPACTS

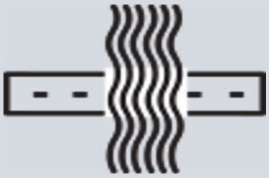
Culverts are a popular and cheaper alternative to bridges at river-road crossings (Figure 5), but can have negative impacts on river morphology, hydraulics and biota, particularly on macro-habitats No. 2 (mountain, alpine and subalpine), No. 8 (Mediterranean mountain and upland) and No. 13 (Boreal-Atlantic large-medium sediment; Table 2). Culverts may hinder fish passage due to high water velocities, low water depth, lack of shelter, high outflows and debris jams (Kemp and Williams, 2008). This can increase fish energy expenditure, vulnerability to predators, angling mortality, and risk of diseases below culverts. Particularly problematic are perched culverts, where there is a head drop at the outflow. Culverts can also affect fish habitat by altering the transport of sediment, woody debris, and organic material.

SOLUTIONS

Some culverts and bridges can be modified to allow fish passage at road crossings, but not all can maintain sediment and wood transport, and many may affect channel morphology. Open-bottom culverts or embedded (e.g., countersunk) pipe-arch culverts allow a natural substrate to form within the channel (Figure 5) and can improve fish passage (Roni et al., 2002).

Figure 5. Examples of culverts (left) and one of the mitigating solutions (right). Photos: Z. Kaczkowski, AMBER.

2.4. FORDS



IMPACTS

The impact of fords on biota, especially on migratory fish, has only recently started to be investigated (Figure 6). Fords can alter the transport of sediments and block the movements of organisms.

SOLUTIONS

In some cases, the removal of unnecessary fords, or improved ford design, can help mitigate their impacts. For example, fords can be redesigned so that they include a section with enough water depth to guarantee fish passage all year.

Figure 6. Examples of fords (photos: Z. Kaczkowski; SSIFI; AMBER).

2.5. RAMPS

IMPACTS

Ramps are ubiquitous in European rivers to reduce bank erosion under bridges and in modified river channels (Figure 7 left), but can disrupt connectivity and migration opportunities for some fish species.

SOLUTIONS

Ramps can be modified to incorporate corridors to allow fish passage in low-flow channels (Figure 7 right; Plesiński et al., 2018).

Figure 7. Examples of a ramp under bridge (left) and mitigating solution (right) (photos: Z. Kaczkowski, SSIFI; AMBER).

3. BARRIER IMPACTS ON NON-FISH BIOTA

Compared to fish, much less is known about the impact of barriers on non-fish biota such as macroinvertebrates and macrophytes. This is in part due to the common misconception that only fish need to disperse and that macroinvertebrates and macrophytes are sedentary and therefore not impacted by barriers.

The impact of dams and weirs on invertebrates is mostly through changes in water quality, hydraulics and river morphology below impoundments, particularly downstream of nutrient-rich (eutrophic) reservoirs. In non-eutrophic reservoirs, the greatest impact comes from changes in summer temperatures that may disrupt development. Nutrients released from the bottom of eutrophic reservoirs can make the river downstream eutrophic and increases the abundance and richness of submerged macrophytes and algae.

Weirs can also impact on the diversity and abundance of macroinvertebrates. For example, some freshwater mussels disperse as larvae attached to the gills of some fish, and if fish movements are disrupted, freshwater mussels cannot colonise new habitats. Likewise, dams and weirs can also have major impacts on the composition and diversity of macrophyte communities (Figure 8) and studies have shown that heavily fragmented rivers tend to have impoverished macrophyte communities.

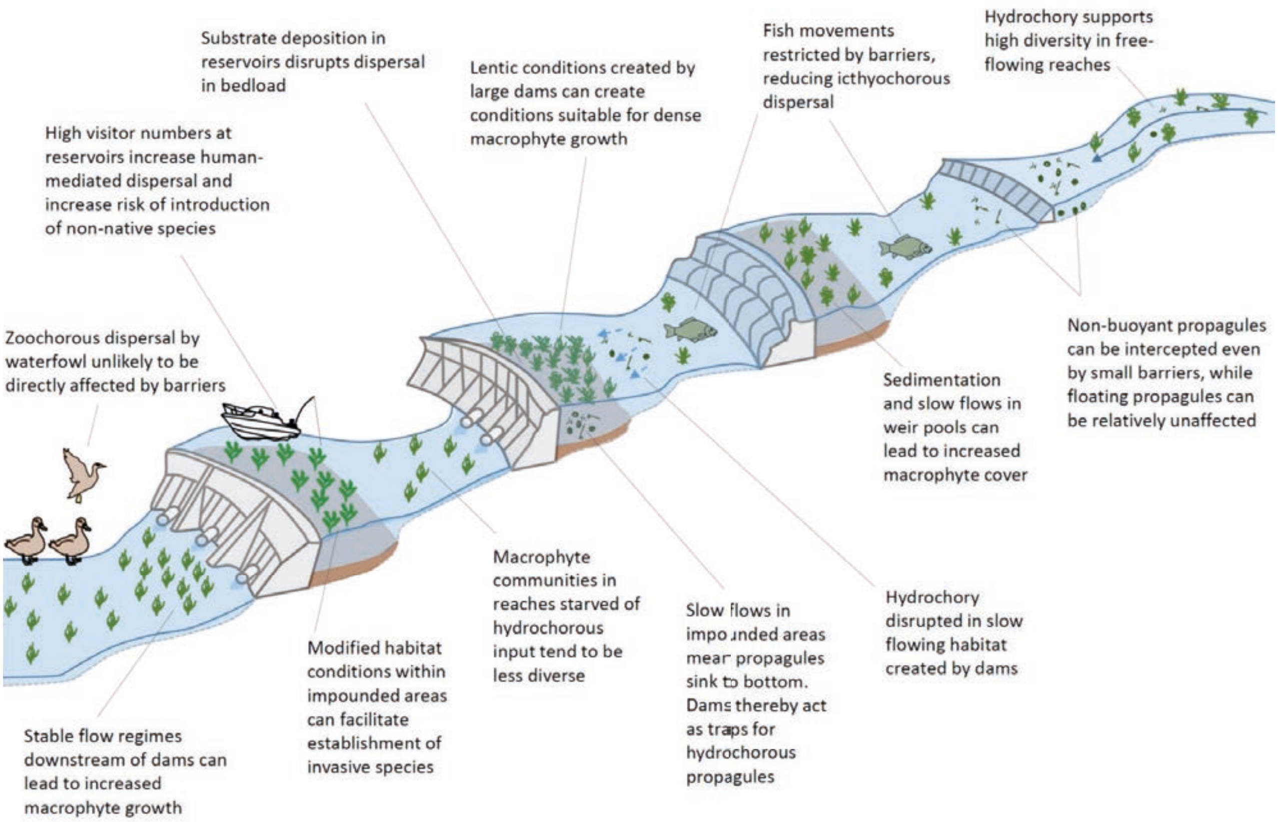


Figure 8. Some impacts of barriers on aquatic macrophytes (adapted from Jones et al,. 2020b)

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