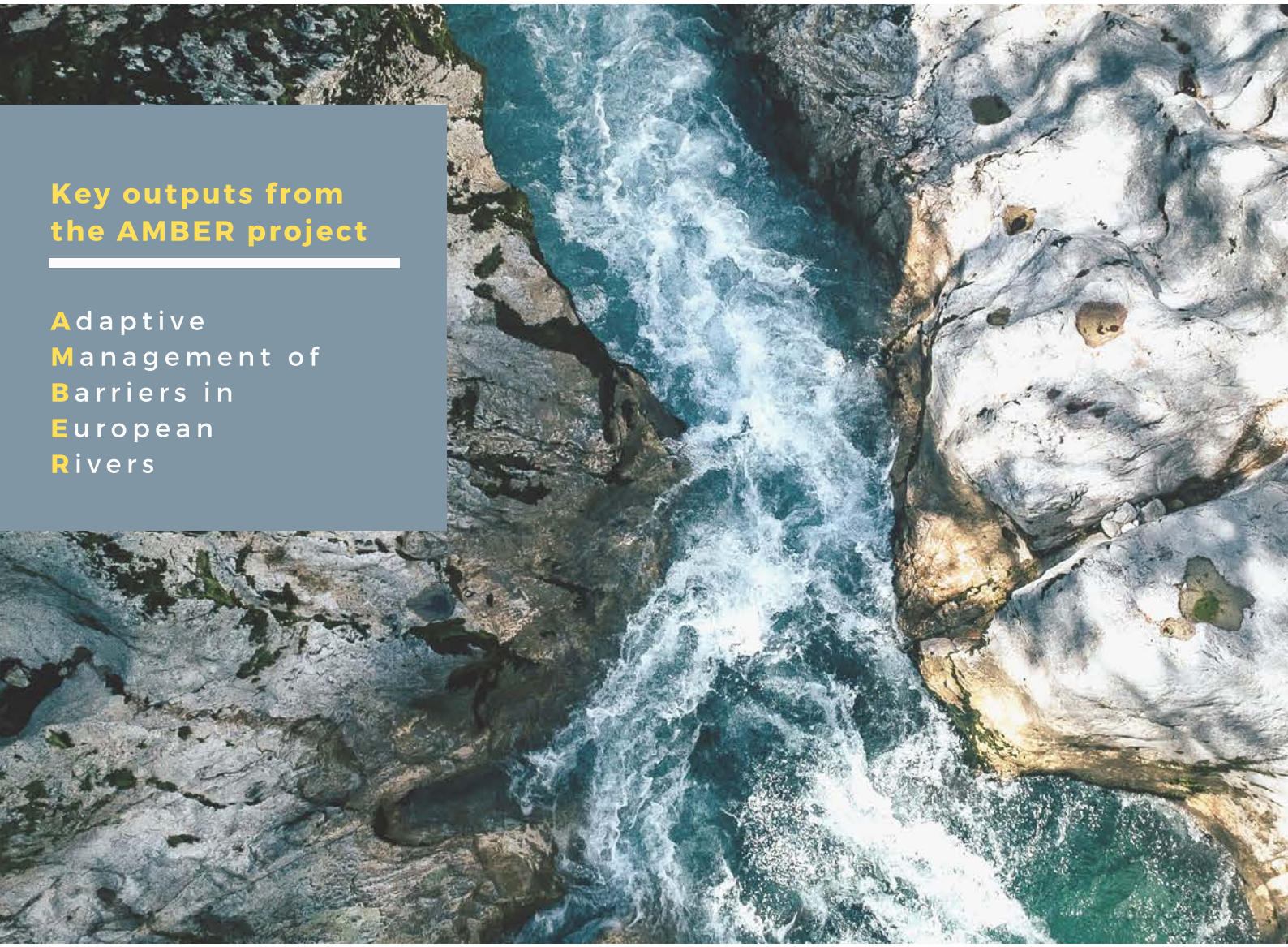
SEPTEMBER 2020

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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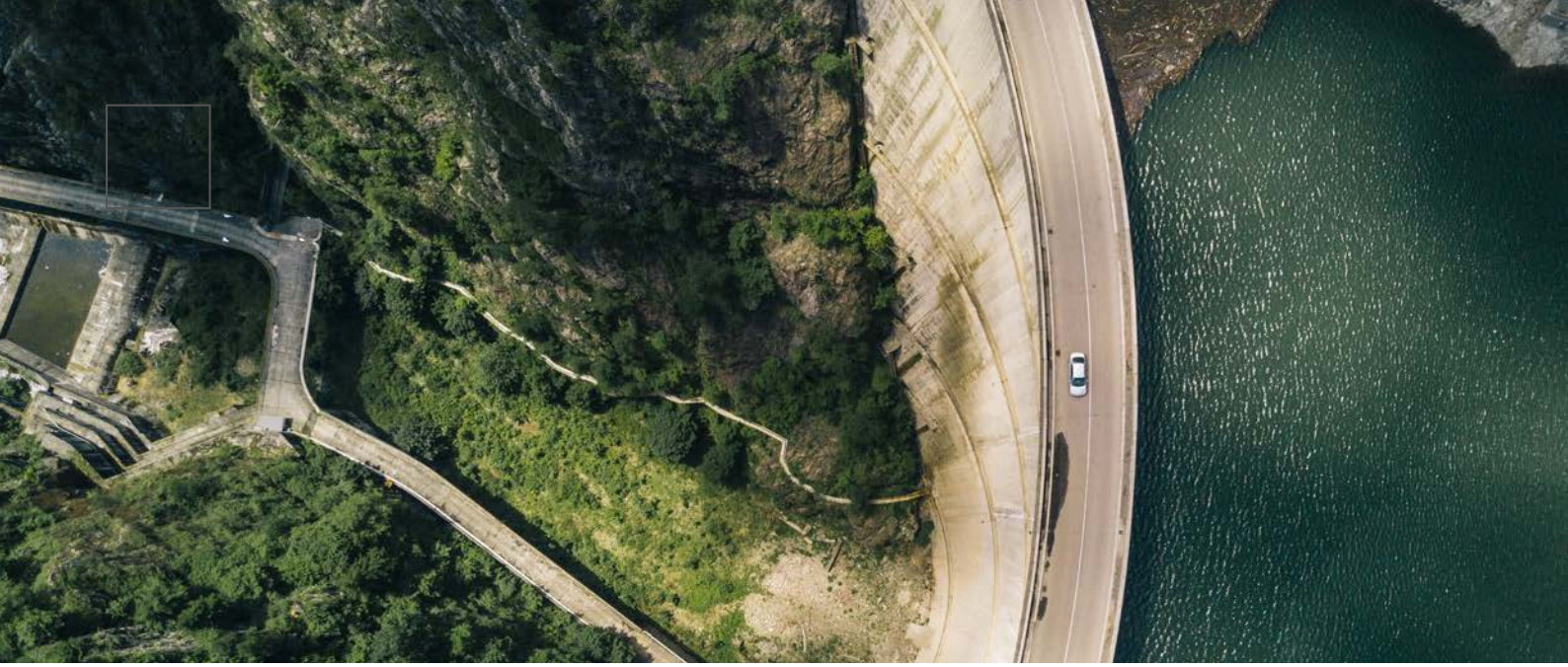


THE NEED

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).

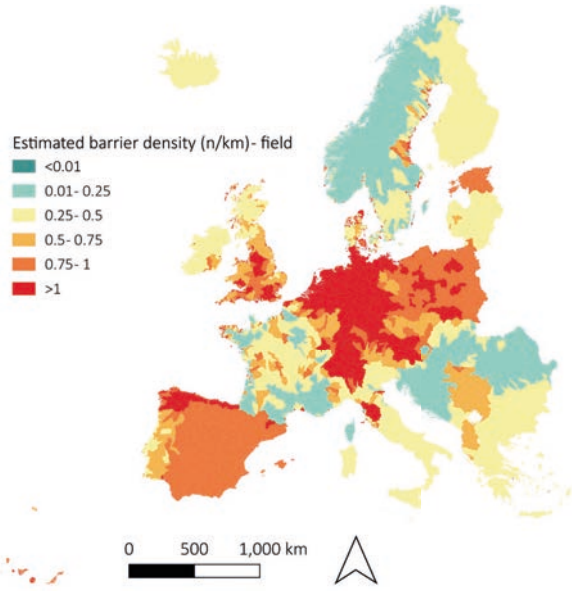


Figure 2. Estimates of barrier density (No./km) across Europe based on ground-truthed barrier numbers (Belletti *et al.*, 2020)

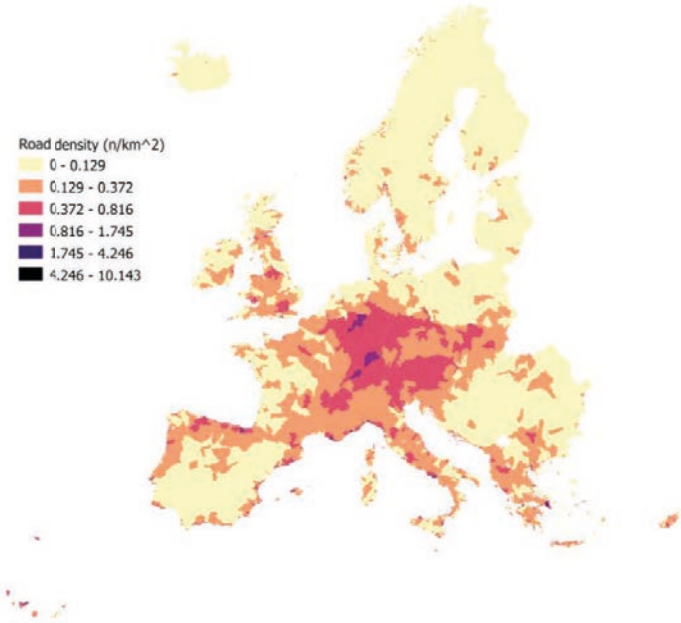


Figure 3. Density of river-road crossings (Belletti *et al.*, 2020).

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).

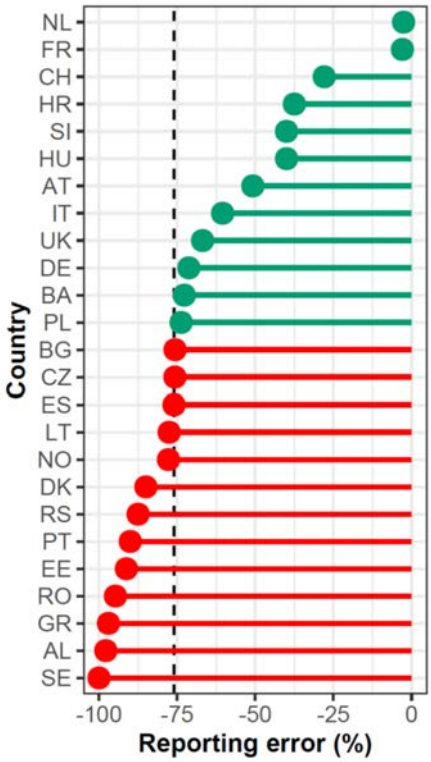
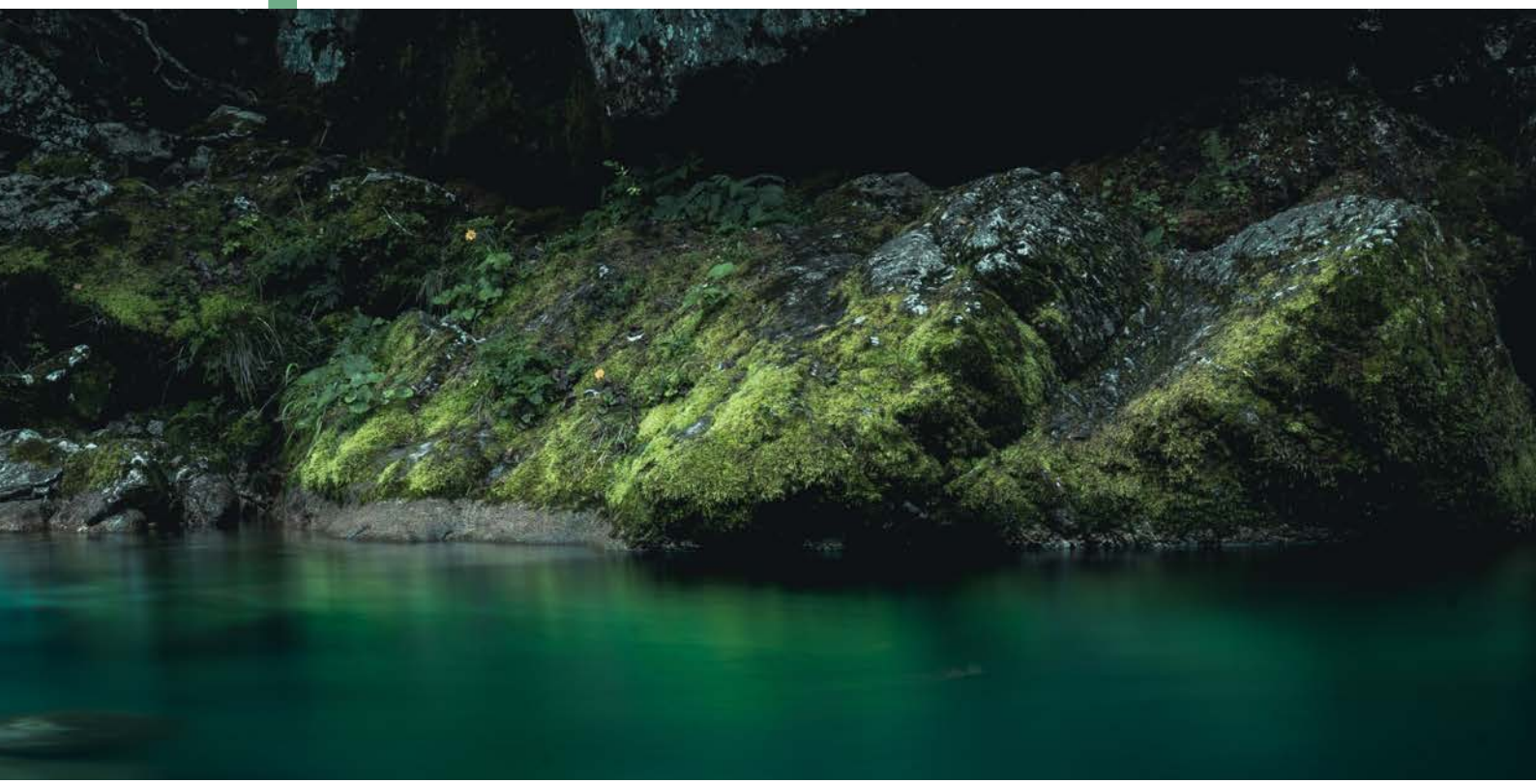


Figure 4. Barrier under-reporting error obtained by comparing barrier records in the existing databases (the AMBER Barrier Atlas) and those derived from field surveys. Values are colour-coded depending on the whether they are above (red) or below (green) the median barrier error across countries (dotted 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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