# Mapping and assessing discontinuities

## Barbara Belletti (POLIMI, Italy)









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# **AMBER**



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## **River connectivity / continuity...**

# ...concerns water, sediment and organisms





#### ...provides ecosystems services











#### Vs. river fragmentation...



## RIVER FRAGMENTATION: WHAT EXTENT? WHERE? HOW TO ASSESS IT?



... and disrupts ecosystems services







#### **Ecological Status of European Lakes & Rivers**



Most EU watersheds fail to meet WFD targets Habitat loss & fragmentation is a key problem!

## Fragmentation of major EU rivers

EEA, 2012

(Loss of accessibility for migratory fish due to barriers > 10 m)

1500 km

1860

50°

500

1000









Accessibility for migratory fish Accessible from sea No barriers, but not connected to sea Inaccessible or poorly accessible Not yet evaluated

Despite the WFD, all major EU rivers remain poorly connected and unaccessible to migratory fish

PBL Netherlands Environmental Assessment Agency, Oct 2015 **AMBER:** Adaptive Management of Barriers in European Rivers Horizon 2020, €6.2 M, 20 partners, 11 countries 2016-2020



8 Universities – Swansea, Durham, Highlands & Islands, Southampton (UK), Cork (Ireland), Oviedo (Spain), POLIMI (Italy), DTU (Denmark)

**4 Industrial partners** - EDF (France), IBK (Germany), Innogy (Germany), Sydkraft (Sweden)

**4** NGOs - WFMF (Netherlands), WWF (Switzerland), CNSS (France), AEMS (Spain)

**4 National/EU Research Centres** - IFI (Ireland), ERCE (Poland), SSIFI (Poland), Joint Research Centre (European Commission)

External advisory board - Laura Wildman (Princeton Hydro, US), Martina Bussettini (ISPRA, IT), Josh Royte (The Nature Conservancy, US), Guillermo Giannico (Oregon State University, US)



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# Adaptive Management of Barriers in European Rivers





## **Challenges for restoring river connectivity in EU**

#### **1. Number of barriers in EU rivers is unknown**

- Definition of 'barrier', country coverage, scale



- 2. ... but certainly more than we can mitigate for
  - Best estimate (based on regional data) =

**0.6 to 1.8 million dams & weirs!** (Garcia de Leaniz, pers.comm)

3. Prioritisation tools are required

#### **Challenges for restoring river connectivity in EU**



Projected changes in river flows over baseline values (JRC 2012)



...where water is most needed!

5. Increase in hydro to meet EU energy targets

6. Impacts of barriers will worsen



#### **Challenges for restoring river connectivity in EU**

Hydroelectricity boom in Europe

- 2020 target of 20% energy from renewables
- Pumped Hydro-Storage (PHS) important for attenuating solar and wind electricity
- Expected investment of €26 billion in PHS alone between 2013 and 2020



*The European Market for Pumped Storage Power Plants, Ecoprog, April 2011. <u>https://setis.ec.europa.eu/publications/setis-magazine/power-storage/europe-experience-pumped-storage-boom</u>* 



## **Challenges for restoring river connectivity in EU** 7. Much is known about restoring fish [salmonid] passage, little about other taxa or fluvial processes







## Challenges for restoring river connectivity in EU 8. Not all barriers can – or should – be mitigated i.e. Aquatic Invasive Species



Topmouth gudgeon



Barrier to prevent immigration of invasive salmonids (NZ)



## Challenges for restoring river connectivity in EU 8. Not all barriers can – or should – be mitigated i.e. cultural heritage



Roman bridge (Cangas de Onis, R. Sella)



## **Challenges for restoring river connectivity in EU** 9. Better <u>decision & prioritization tools</u> are needed!



Dendritic connectivity index

#### **Barrier Impacts:**

- Number
- Location
- Passability (?)

#### **Barrier Mitigation**:

- Cost
- Opportunity
- Benefits (?)

## New opportunities for restoring river connectivity

environmental DNA (eDNA)

· organisms or their parts were not isolated

from a bulk environmental sample

e.g. soil, water, air

#### 1. New technologies

• eDNA/meta-barcoding



• Drones for quick surveying & remote sensing



Modelling

## New opportunities for restoring river connectivity

- **2.** Citizen science & local engagement
- Smartphone apps/ CS portals









• Google Earth







- European stream barrier inventory and ATLAS (2019)
- Barrier assessment smartphone app (Spring 2018)







- Adaptive barrier management guidance and decision support tools:
  - River infrastructure assessment and classification software tool (passability and hydropower potential) (2018)
  - Toolkit molecular methods (2017)
  - Remote Sensing based Rapid habitat assessment methodology (2018)
  - Habitat modelling toolkit (2018)
  - Barrier impacts on sediment connectivity (2018)



- Book: Best Practice Guidance on Adaptive Barrier Management in Europe (2020)
- Scientific Publications

https://amber.international/peer-reviewed-publications/



#### **6 Main Case Studies**



Barrier impacts on sediment connectivity CASCADE - CAtchment Sediment Connectivity And DElivery



# **THE AMBER ATLAS**

# AN EUROPEAN ATLAS OF RIVER BRRIERS

**European Barrier Atlas** 

POLIMI: Barbara Belletti, Simone Bizzi, Andrea Castelletti JRC: Wouter Van de Bund WFMF: Rosa Olivo del Amo, Pao Fernandez Garrido CNSS: Gilles Segura



#### **River fragmentation: a worldwide issue**



#### **River fragmentation in Europe: state of art** Continental, National, Regional scale







#### **River fragmentation in Europe: state of art** Continental, National, Regional scale

Continental + national



All barriers (also < 10 m)



#### **River fragmentation in Europe: state of art** Continental, National, Regional scale

Continental + national + regional



All barriers (also < 10 m)



#### Type of barriers for different datasets







National inventory Regional inventory Yet to be contacted

Created with mapchart.net @



## Data availability: a first survey

	WORLD	NATIONAL			REGIONAL		
	GRanD	Sweden	France	Switz.	US	Guadiana Basin	Ebro Basin
Latitude/Longitude	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Name of obstacle	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Name of River Basin	Yes	No	Yes	No	Yes	Yes	No
Name of river	Yes	No	Yes	No	Yes	Yes	Yes
Height	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Width	Yes	Yes	No	Yes	Yes	Yes	Yes
Storage Volume	Yes	Yes	No	Yes	Yes	No	No
Date built	Yes	Yes	No	Yes	Yes	No	No
Type of obstacle	No	Yes	Yes	Yes	Yes	Yes	No
Origin of obstacle (natural / artificial)	Yes	Yes	No	Yes	No	Yes	No
Construction type/material	No	Yes	No	No	Yes	Yes	No
Obstacle conditions (good, bad)	No	No	No	No	Yes	Yes	No
Functioning uses (hydropower, flood mitigation etc)	Yes	No	Yes	?	Yes	No	No
Fish passage/other facilities	No	Yes	Yes	No	No	Yes	Yes

Update: November 2016



River fragmentation of European rivers is largely unknown





## **Need for a pan-EU ATLAS**

#### PROBLEM (many) ...

National and regional (and provincial!) databases





Databases "incomplete"



WDF & Ecological state Scattered data availability



Fragmentation extent?

...SOLUTION (a starting point)





#### **AMBER ATLAS**

#### Barrier ID-card



#### **ATLAS outcomes**





#### **ATLAS** outcomes

JRC TECHNICAL REPORTS

Continental scale indicators for river fragmentation caused by barriers (based on DAMPOS)

#### Assessment of the effectiveness of reported Water Framework Directive Programmes of Measures

Part III – JRC Pressure Indicators v.1.1: nutrients, urban runoff, flow regime and hydromorphological alteration

Alberto Pistocchi, Alberto Aloe, Bruna Grizzetti, Angel Udias, Orga Vigiak, Bernard Bisselink, Favçal Boursoui, Ad de Roo, Emiliano Gelati, Marco Pastori, Wouter van de Bund



We expect that the AMBER ATLAS can improve this kind of analysis



#### **ATLAS outcomes**



Geographic or socio-economic drivers for barrier distribution (and river fragmentation)



Link between river fragmentation and the ecological state

under WFD

River fragmentation and... sediment connectivity, flood risk, ecological connectivity







#### Data validation and update



Coming soon... Stay tuned!

#### DATA VALIDATION



Dam existence

Effective data coverage

#### DATA UPDATING



Citizen science

#### BARRIER MONITORING (?)



#### Data collation strategy and progress



Barrier density (Amber countries) Barriers > 10 m





Belletti, Bizzi et al., June 2017 (Deliverable D1.2)

#### Data availability: first results

Key parameters	Denmark	France	Germany	Ireland	Italy	Netherlands	Poland
Source_ID	х	Х		Х	NA	х	х
URL (main)	NA	http://ww w.sandre, eaufrance, <u>fr</u>			http://w ww.regis troitalian odighe.it	http://www .sportvisseri inederland. <u>nl</u>	NA
Country	х	х	-	х	X	Х	х
X_coord	х	х	2	х	х	х	х
Y_coord	х	x	÷	х	Х	х	Х
River	х	х		х	x	х	х
Basin	х	х		Х	Х	х	Х
Height	NA	х	-	х	х	NA	х
Туре	х	X	۲	х	NA	x	х
Year	NA	NA		NA	NA	NA	NA
Fish pass	х	Х		NA	NA	х	NA
)						The state of the s	
Key parameters	Spain	Sweden	Switzerland	England	Scotland	Wales	Northern Ireland
Source_ID	Х	x	х	х	Х	х	NA
URL (main)	http://w ww.map ama.gob. es	https://bio topkarteri ng.lansstyr elsen.se	https://s.geo .admin.ch/6f 35d18806	NA	http://ww w.sepa.org .uk	NA	https://w ww.daera ni.gov.uk
Country	х	х	Х	х	x	х	x
X_coord	Х	x	х	Х	Х	х	х
Y_coord	Х	х	х	х	Х	х	Х
River	NA	×	х	Х	Х	х	NA
Basin	NA	×	NA	X	NA	×	NA
Height	Х	х	х	Х	Х	x	NA
Туре	Х	Х	x	Х	Х	х	NA
Year	NA	NA	NA	NA	NA	NA	NA
Year	NA	NA	NA	NA	NA	NA	NA
Eleb pare	NΔ	×	NA	×	NA	NA	NA

#### **Amber countries**



Barrier density (Amber countries) Including barrier < 10 m





Belletti, Bizzi et al., June 2017 (Deliverable D1.2)



#### Barrier types (Amber countries)





#### Fish pass (presence and types)





#### Need for data validation



INGILLE	Description	
Picture	A photo of the barrier – provide a reference for the picture	
Location	Lat/Long coordinates for e.g. via GPS chipset on phone	
Date	Date of record in format day/month/year	
Barrier type	Dam, weir, culvert, ford, ramp and bed sill, sluice, unknown	
Barrier height	<0.5 m, 0.5 - 1.0 m, 1.0 - 2.0 m, 2.0 - 5.0 m, 5.0 - 10.0 m, >10.0 m	
Barrier use	Barrier still useful/in-use, Y/N/don't know	
Barrier width	Full width, Y/N	



#### **Field validation: barrier types**



DAM



WEIR



SLUICE



FORD



CULVERT

RAMP & BED SILL











Comparison with other existing databases (regional, basin authorities...)

- Scrivia and Dora Baltea: none of the databases at the local level record the barriers that has been observed during the field work, except 1 dam of national interest along the Dora Baltea

- Orco river: 2 barriers observed during the field work are also displayed in a regional database for flood and soil defenses (a weir and a ford). 2 more fords are also recorded in the regional DB but not observed during the field work



- Arno river: 9 out of 11 barriers are recorded in the database from the northern hydrographic district



#### Data validation: test application in Italy



#### **ATLAS expected outputs: in progress**



#### Expected barrier density at Pan-Eu scale inferred by:

- Field Validation datasets
- Physical Setting
- Socio-Economic Drivers
- •





Natural Resources Management



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