

45-50 mn + discussion

# The restoration of the Rhône, France : feedbacks on 25 years of implementation and monitoring.

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# The Rhône river

One of the largest European rivers

First freshwater input to the western Mediterranean basin

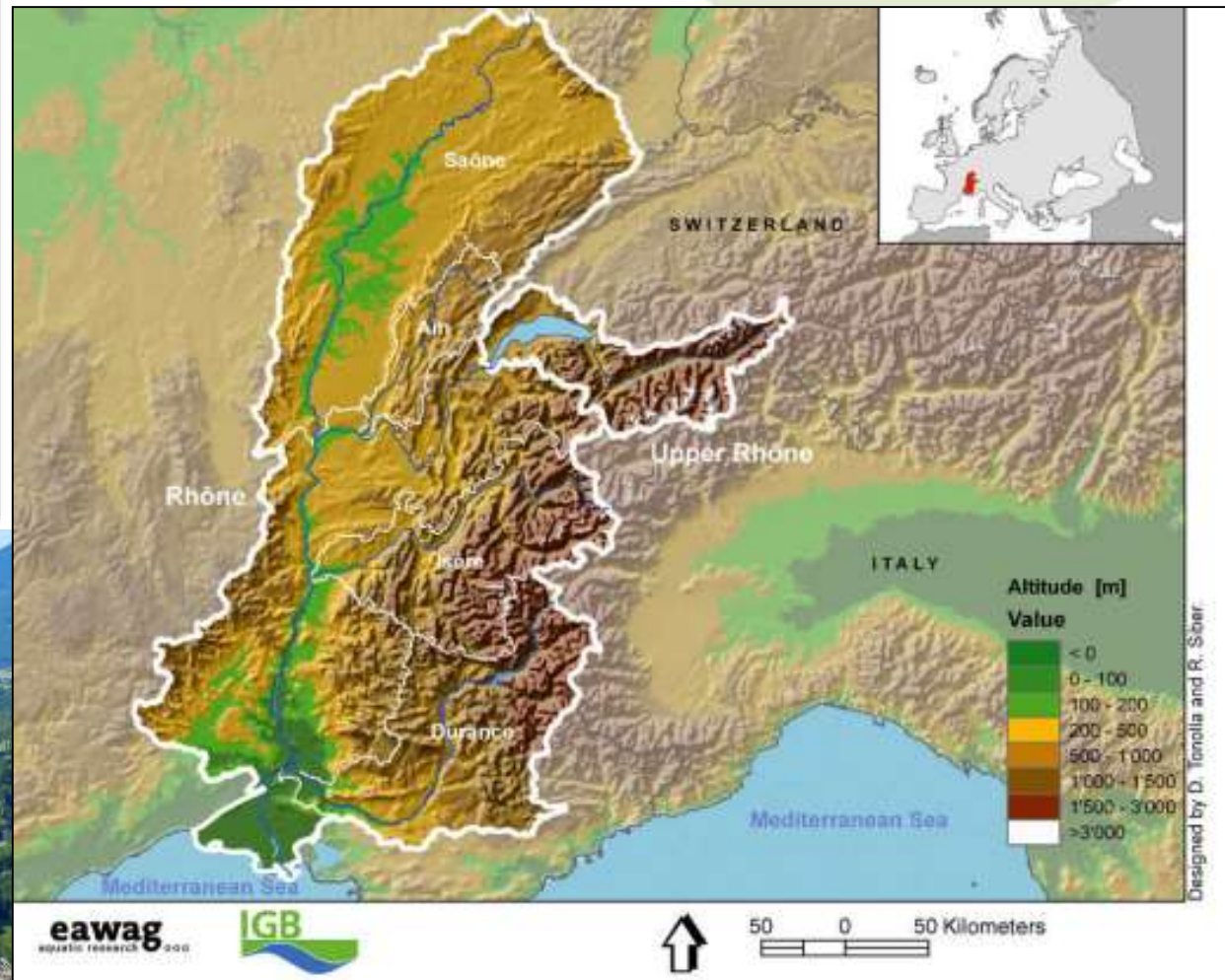
560 km in France  
(800 km in total)

Watershed: 98,000 km<sup>2</sup>

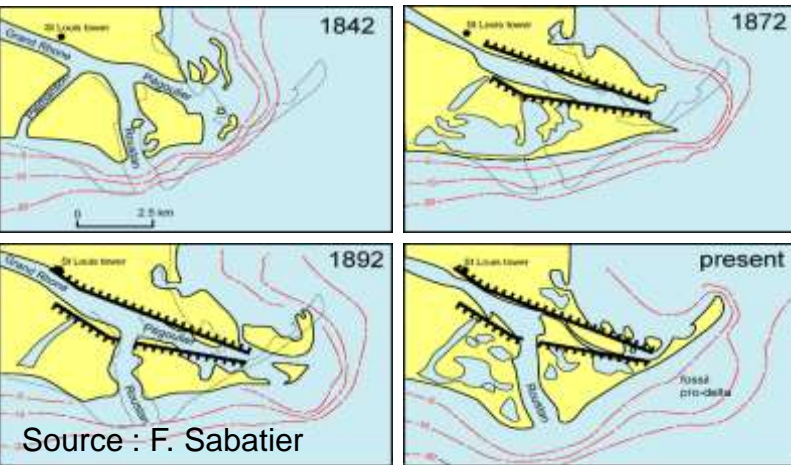
Mean annual flow at the  
mouth: 1,700 m<sup>3</sup>/s

Q50 : 10,000 m<sup>3</sup>/s

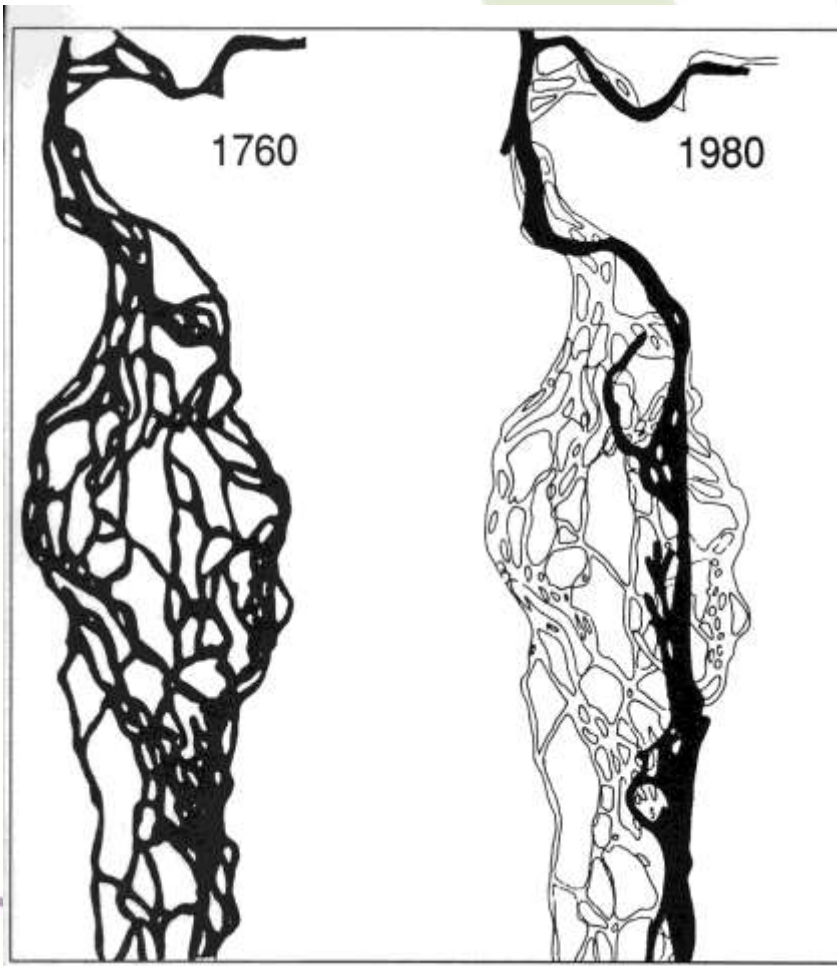
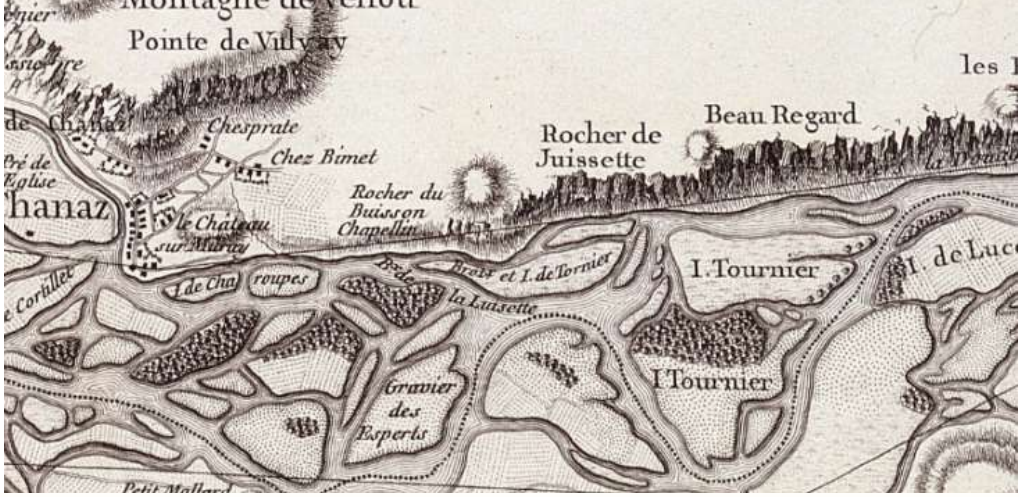
Hydrographic district



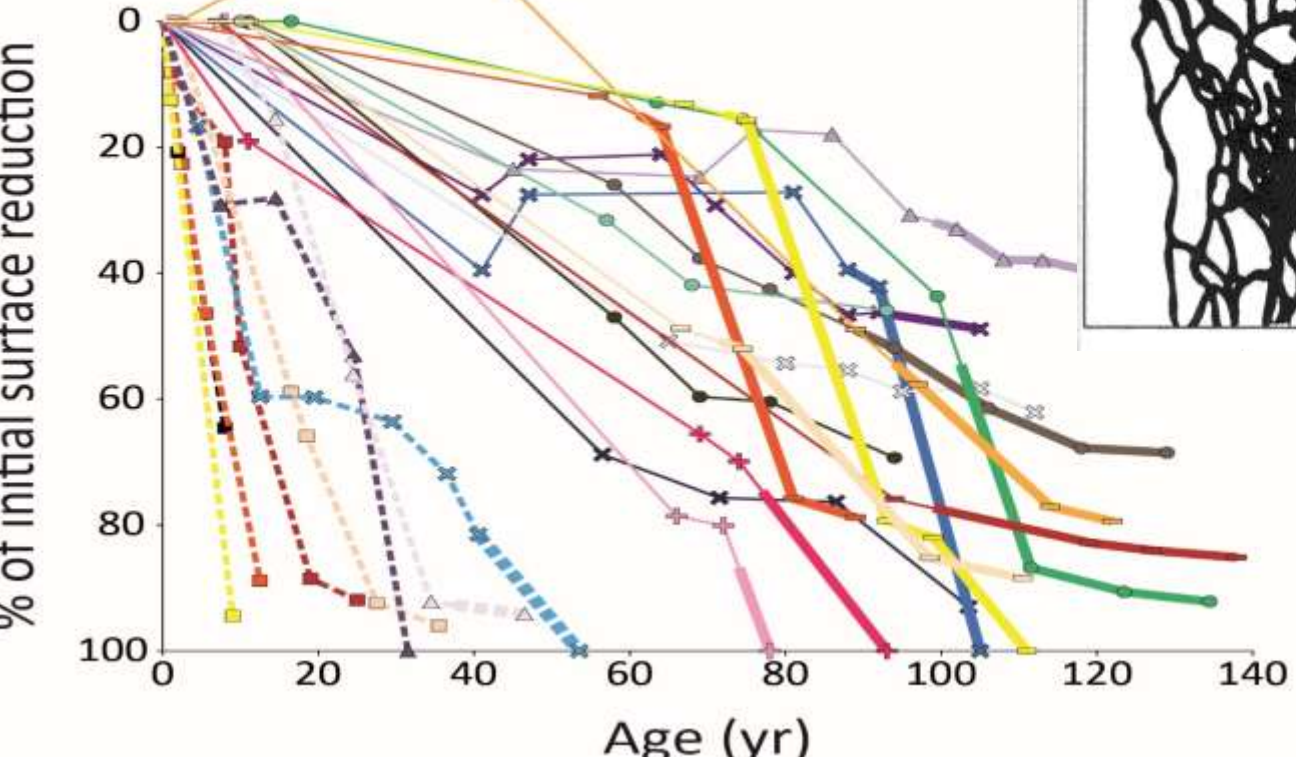
Regulated between 1850 and 1930 for navigation purposes... (embankments, groynes, walls)



1884-1938:  
Casiers Girardon

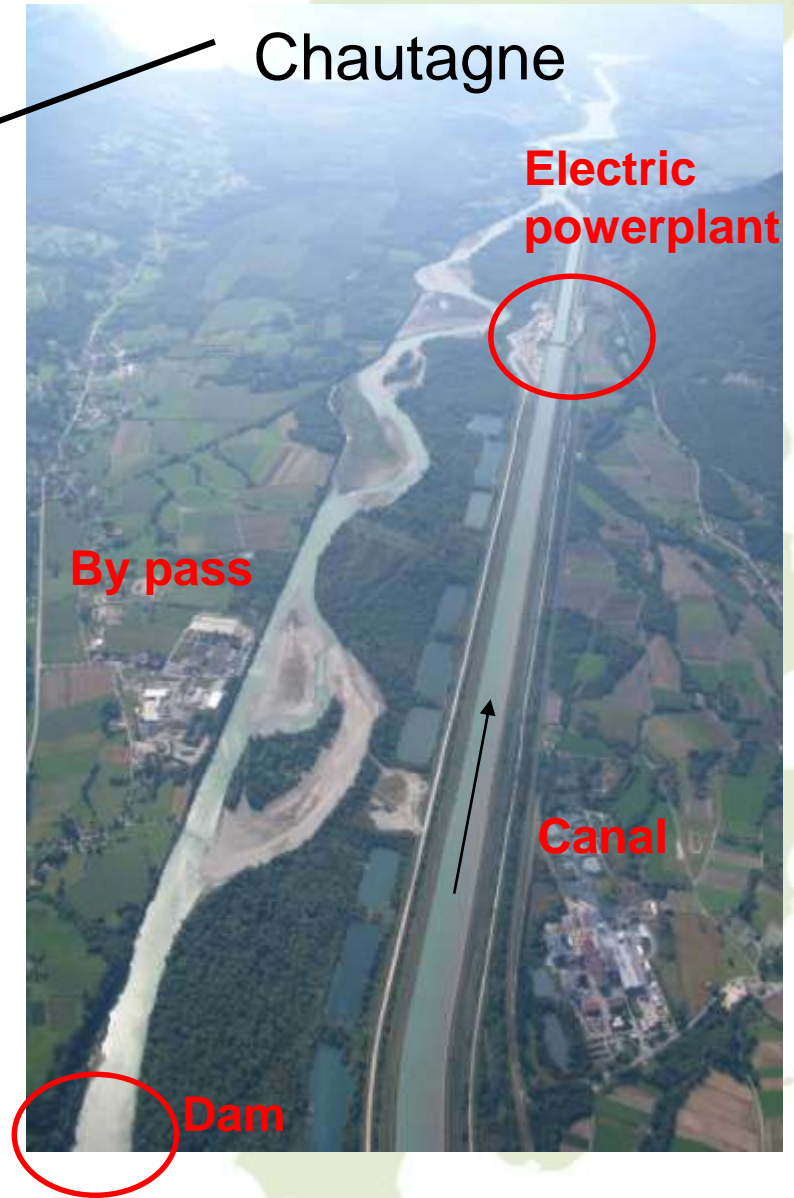
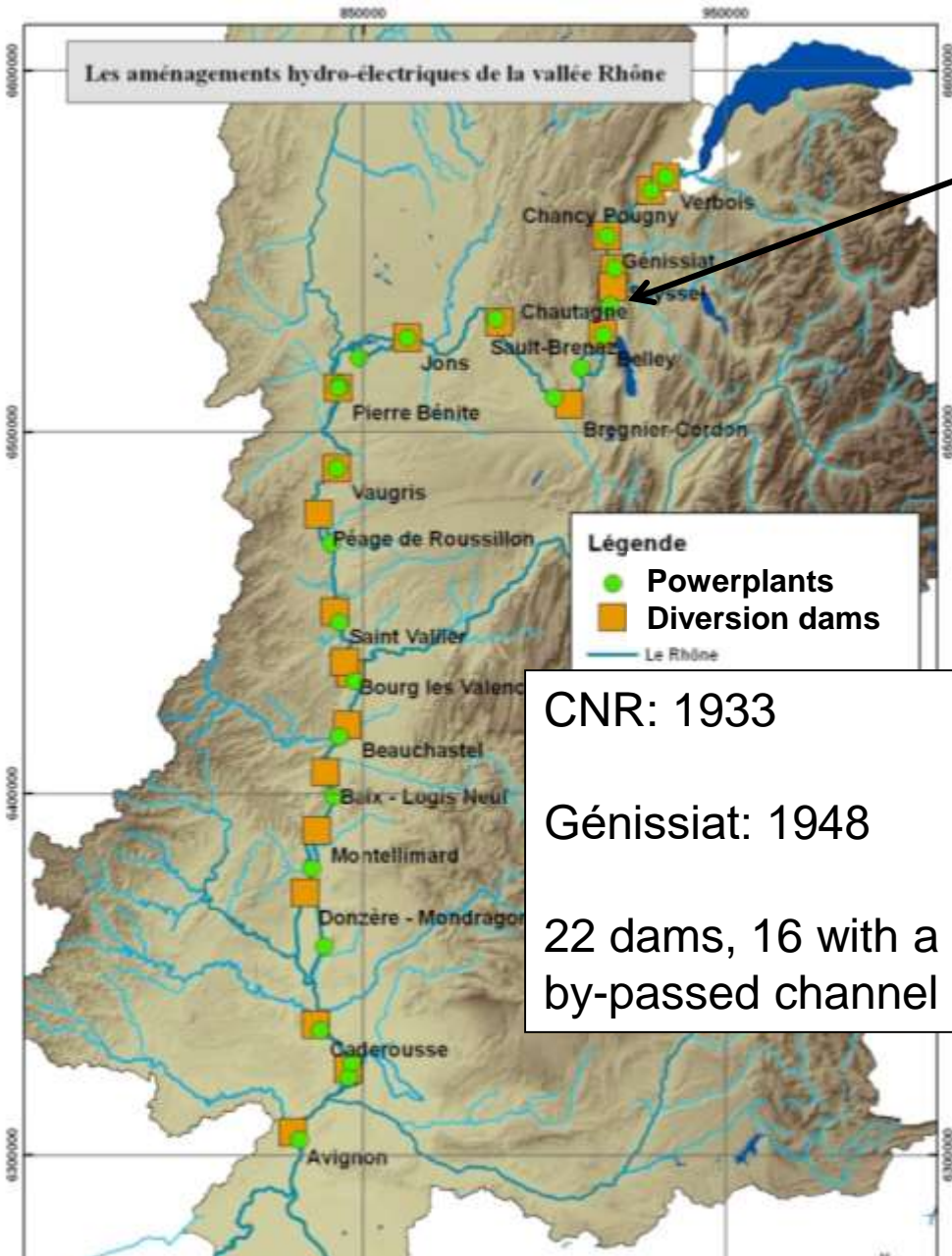


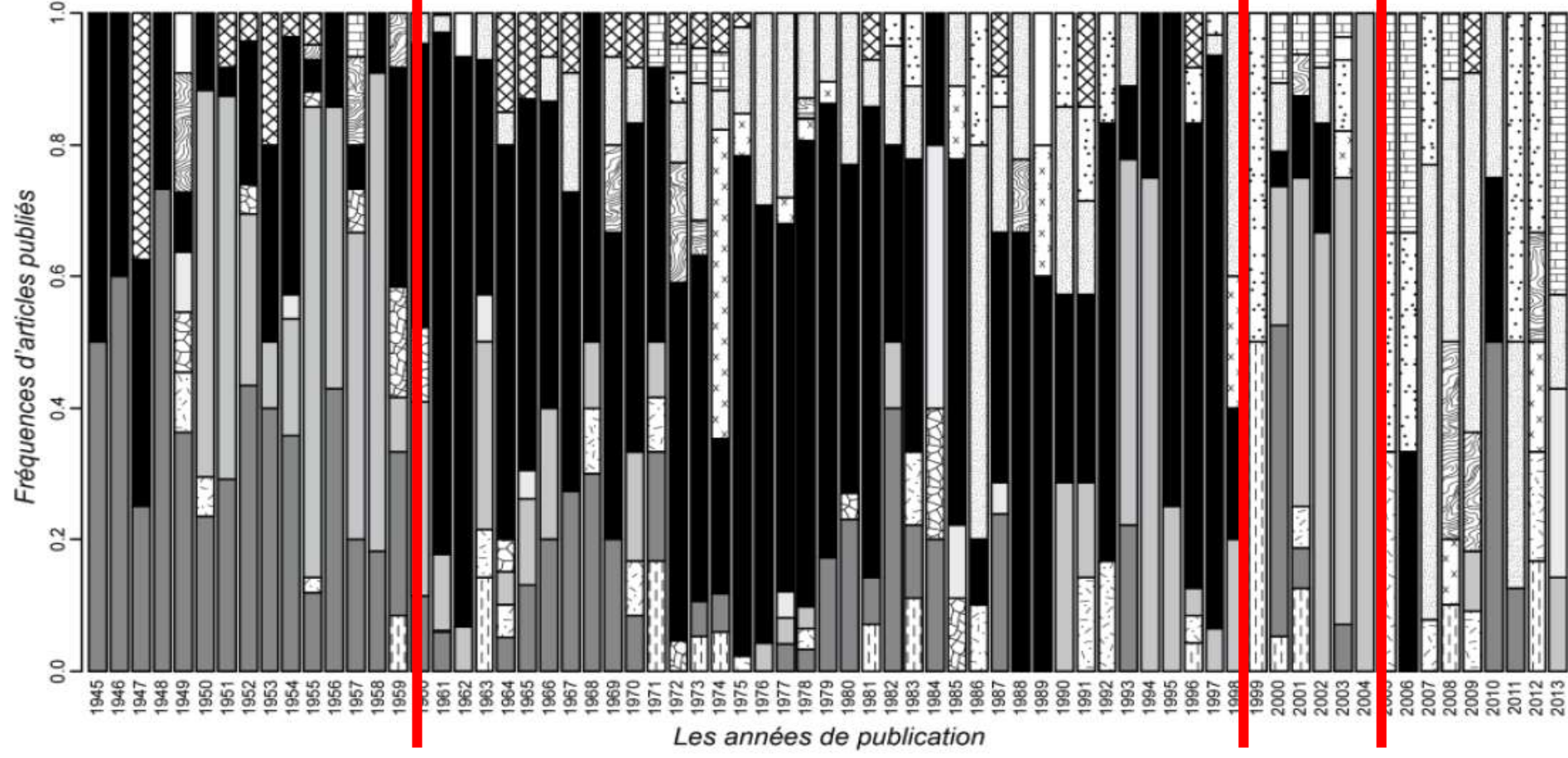
Depret et al. 2016  
Geomorphology



Evolution of Rhone in Chautagne, *Bravard 1993*







Comby, 2015

Séries chronologiques des thèmes rhodaniens dans *Le Monde*

- ⊠ Traversée
- ▨ Tourisme
- Sécheresse
- ⋯ Reconquête
- ▤ Pollution
- ▩ Patrimoine
- ⊠ Nucléaire
- Navigation
- Loisirs
- ▩ Irrigation
- ▨ Inondation
- ▩ Biodiversité
- Barrage
- ▤ Approvisionnement



# 1980's: Understand human impacts

1982  
Cartogr  
polythématique



1990  
Assises  
nationales de  
l'eau



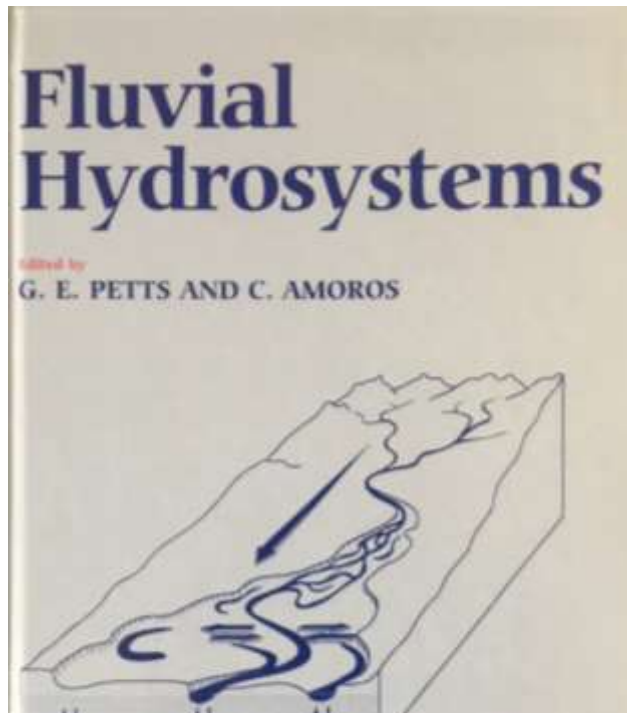
1993  
Fluvial  
hydrosystem



1982 RGL  
hydrosystème



1992-1997 - Water law and  
SDAGE : A fast flowing river

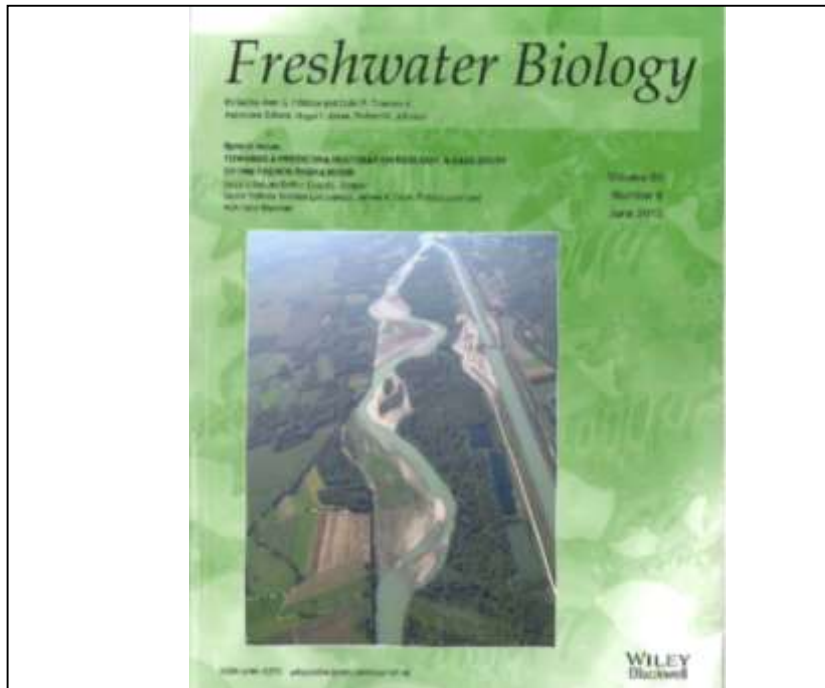
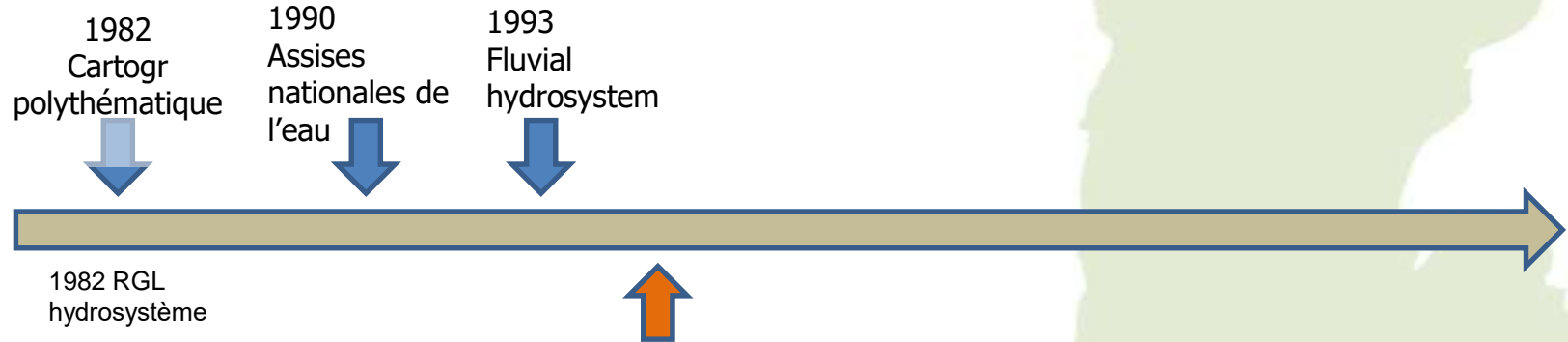


## What's going on?

Hydrosystem concept  
Multi-scale approach  
Interdisciplinary perspective



# 1990 – 2000's: emergence of restoration and monitoring



1995-2018

## Can we restore? How?

- Reference / rehabilitation / trajectory (Henry and Amoros, 1995; Dufour and Piegay, 2009)
- Monitoring, indicators
- Models
- Evidence of success
- Sustainable (forms versus processes, climate change)



# Restoration issue?

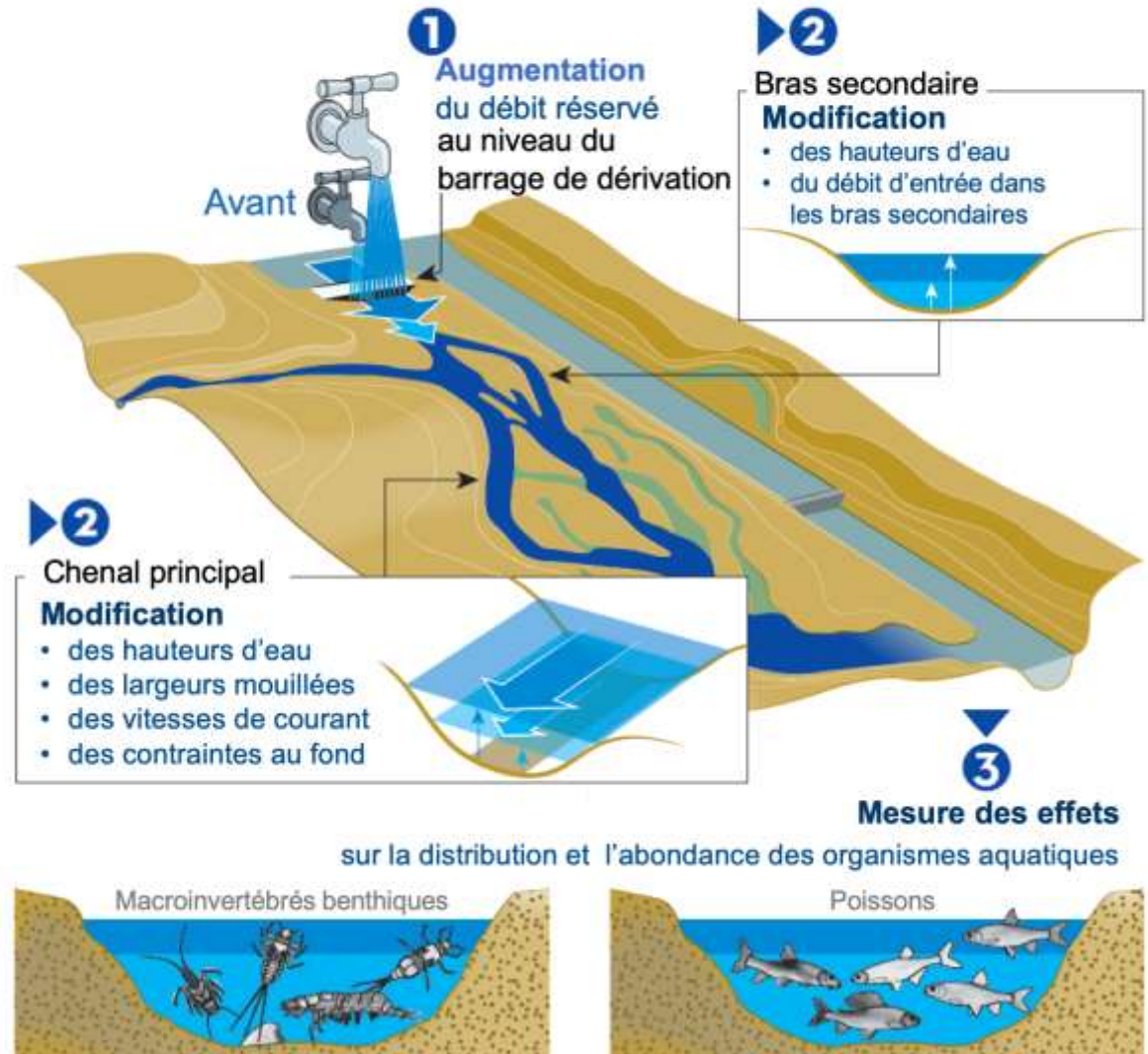
- Fish ladder for migratory species



# Restoration issue?

- Minimum flow increase in by pass sections

## Chenaux court-circuités Débits réservés



(~110km/522 km)

By-pass reaches	Mean annual flow m <sup>3</sup> .s <sup>-1</sup>	Date of restoration	Minimum flow m <sup>3</sup> .s <sup>-1</sup>	
			BEFORE	AFTER
Chautagne	410	07/2004	10-20	50-70
Belley	410	07/2005	25-60	60-90
Brégnier-Cordon	435	07/2006	80-150	80-150
Canal de Miribel	598	-	30-60	30-60
Pierre-Bénite	1030	09/2000	10-20	100
Péage-de-Roussillon	1050	01/2014	10-20	50-125
Baix-Le-Logis-Neuf	1475	01/2014	10-20	74,5
Montélimar	1490	01/2014	15-60	75,4
Donzère	1490	01/2014	60	75,4

Hauteur d'eau 1.2 m  
Vitesse 0.07 m/s

2.1 m  
0.35 m/s

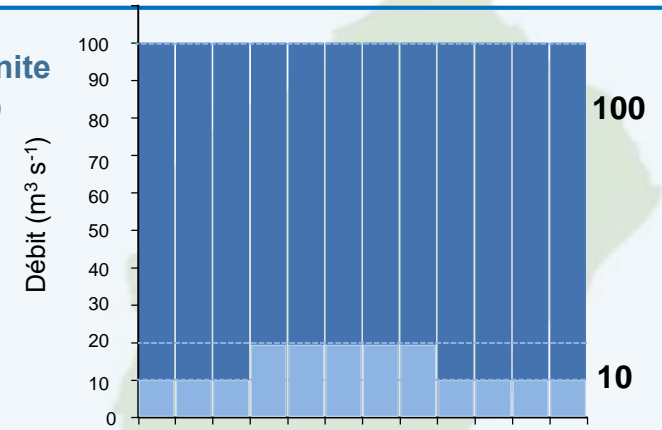


1996

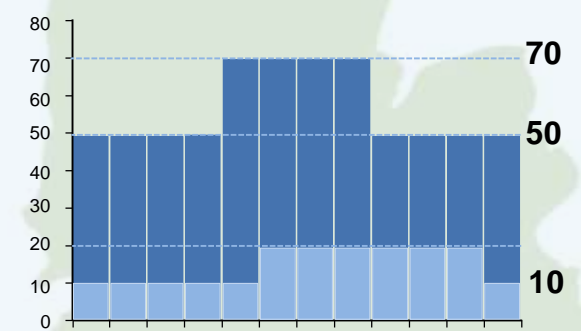


2002

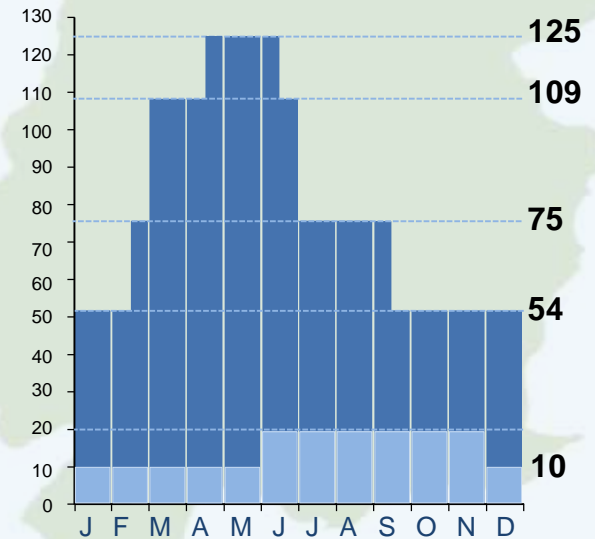
### Pierre-Bénite (2000)



### Chautagne (2004)

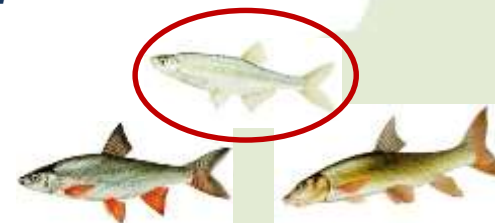


### Péage de Roussillon (2014)

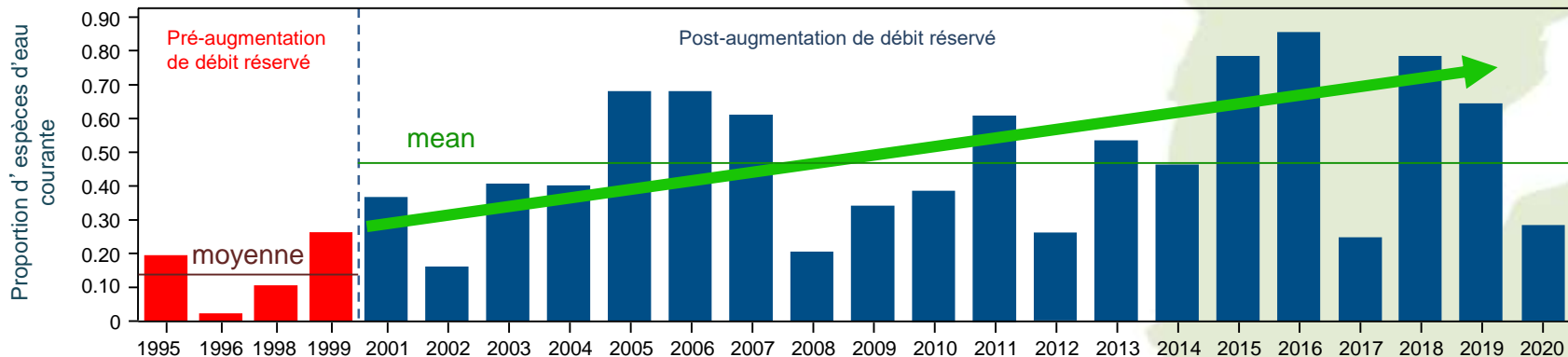


# Proportions of fast flowing species

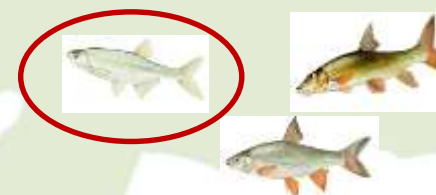
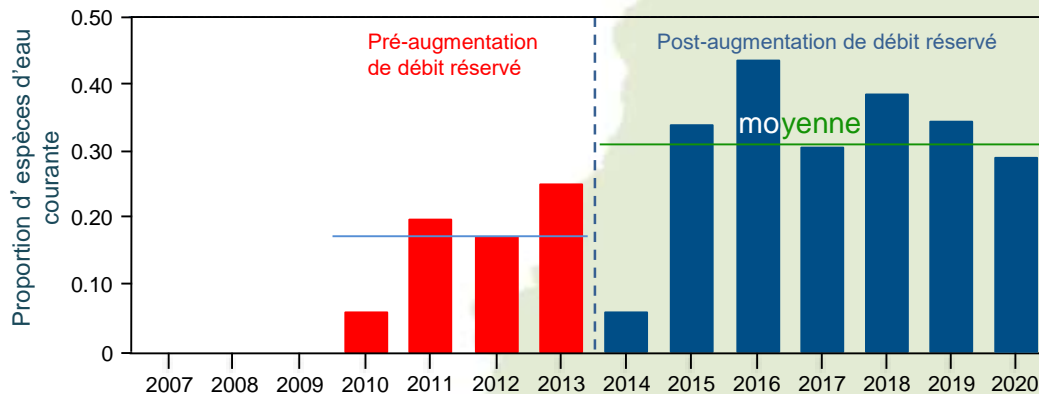
## Lower-Rhône



### Pierre - Bénite



### Baix-Le-Logis-Neuf

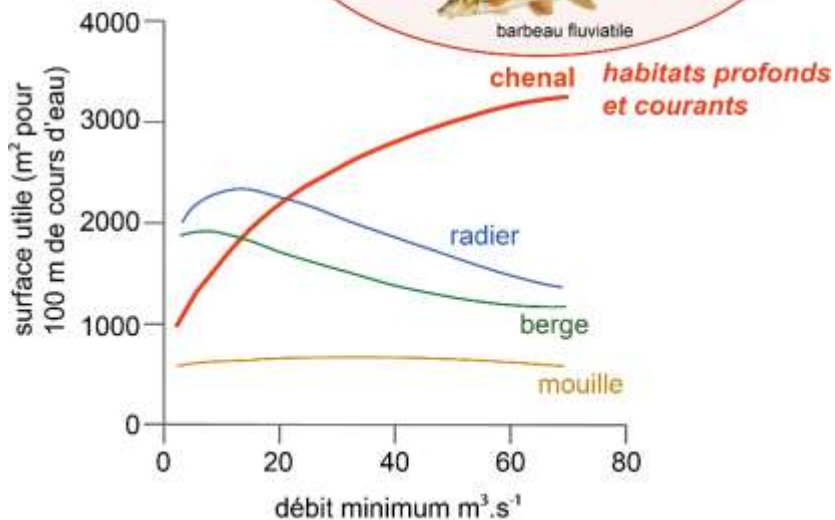


Linked between minimum flow

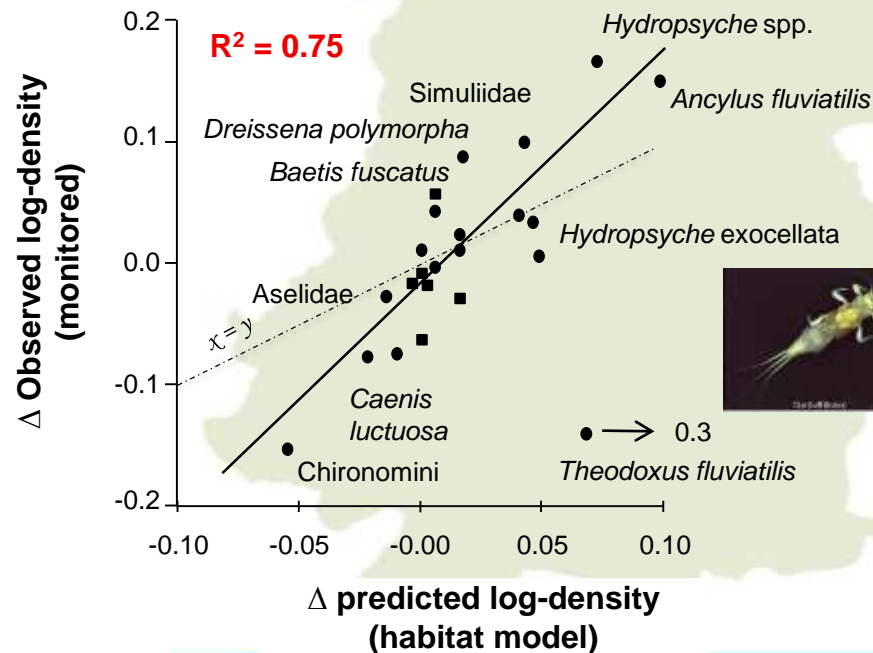
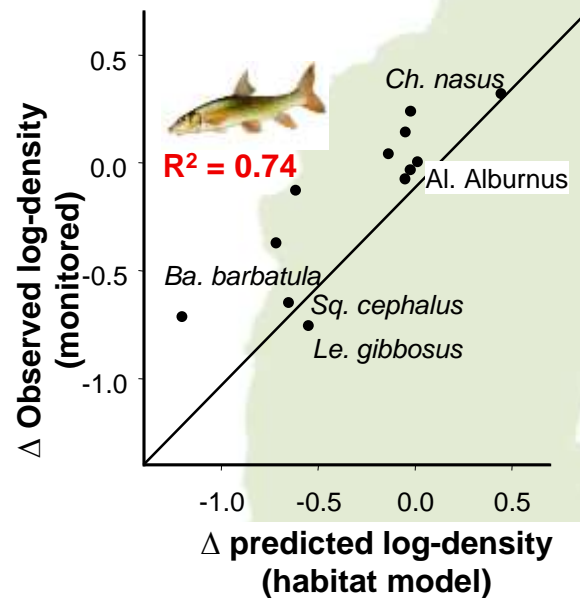


Fish community

Fast flowing  
Fish species



Pierre-Bénite by-pass reach



# Restoration issue ?

- Reconnect and rewater former channels (~40 sites in 15 years)



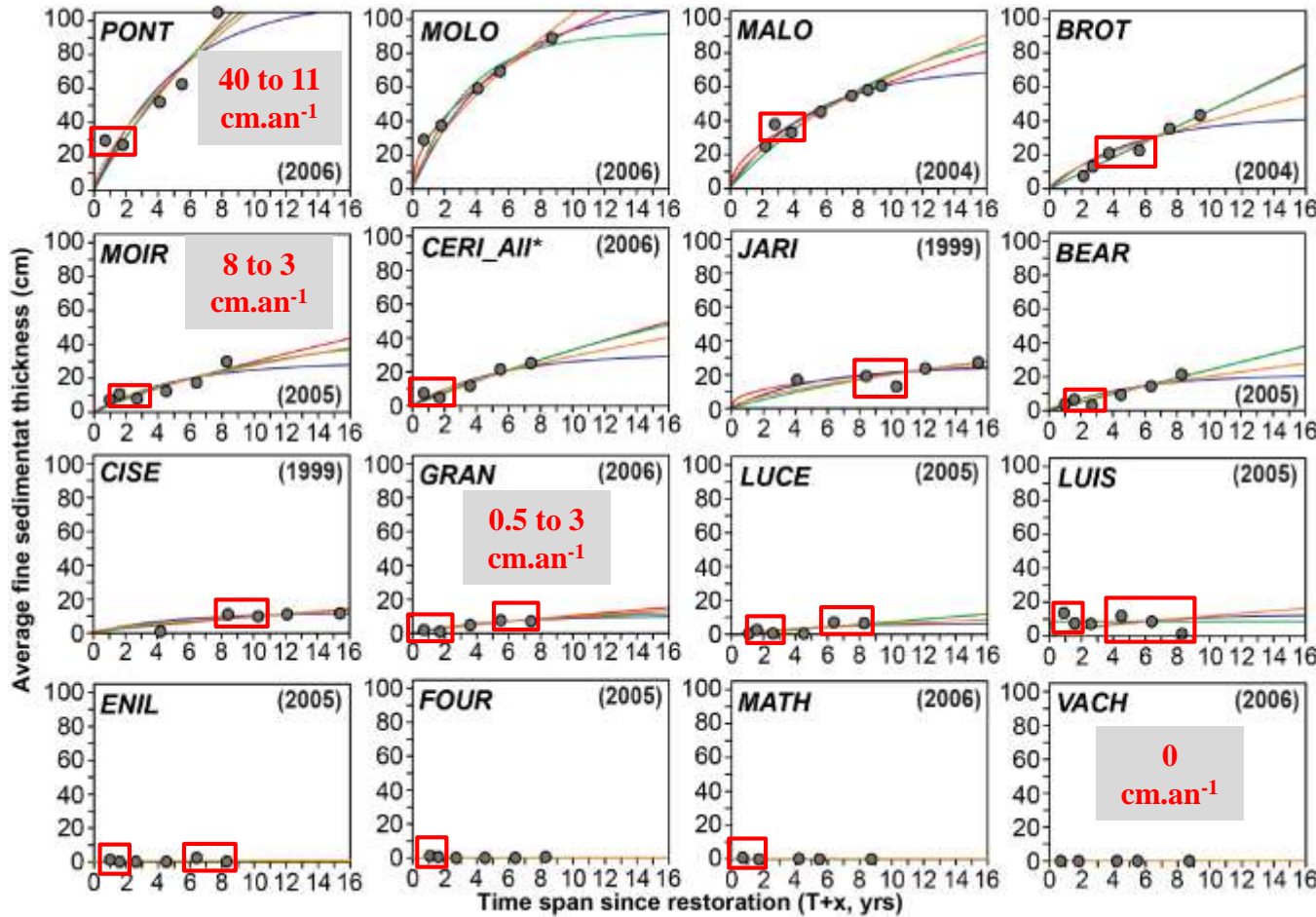
Excavated and rewatered former channels in Pierre Bénite (1999)



Pierre Bénite  
4th March 2002  
15th March 2012



# Propensity of channels to accumulate fine sediment: general trends

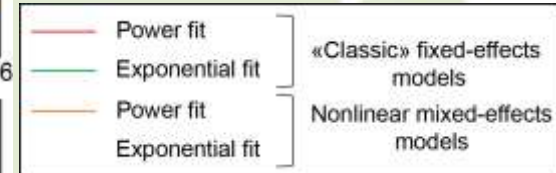
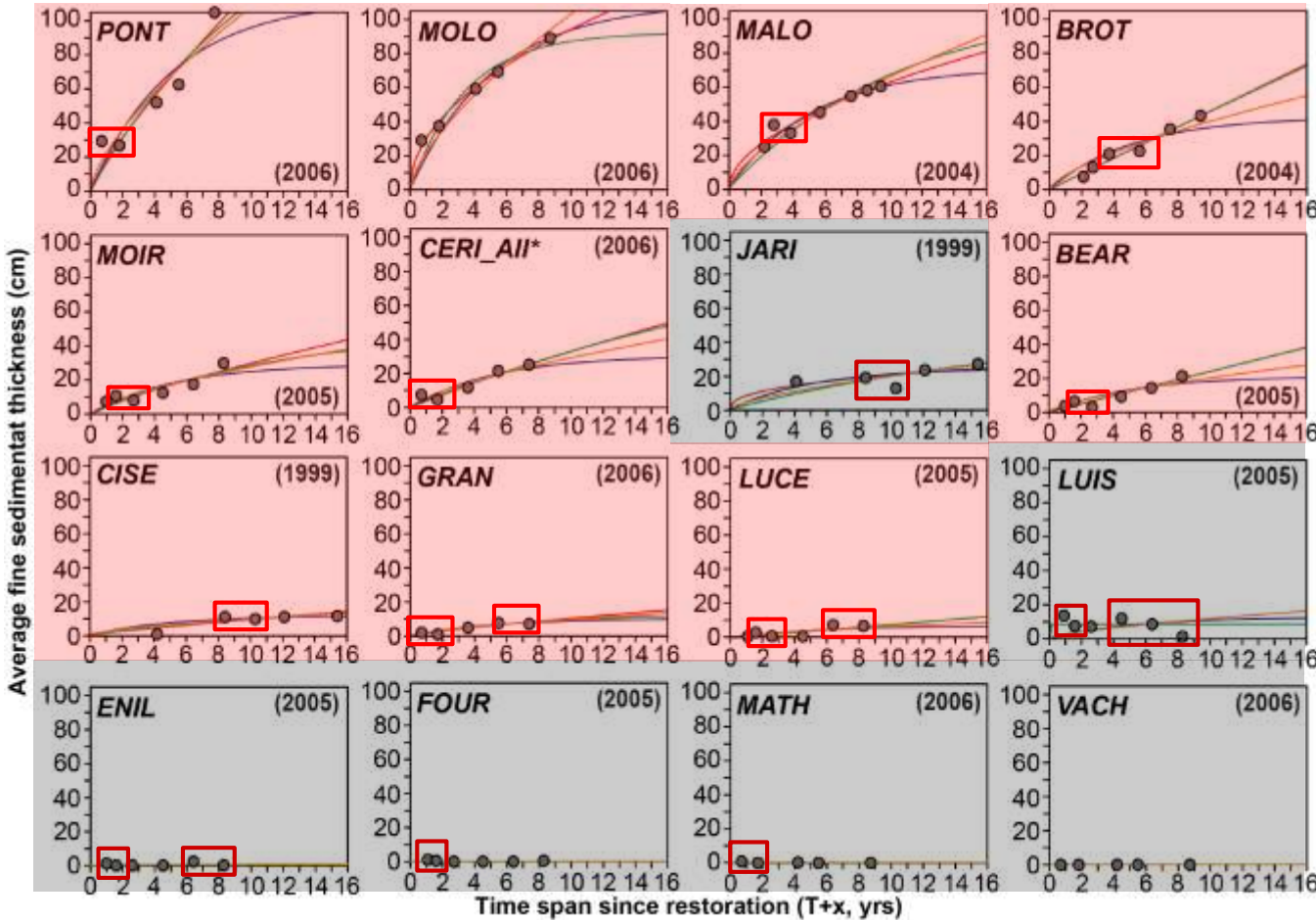


Scouring of fine deposits

- A large range of fine sedimentation dynamic

- Scouring processes (*i.e.* self-rejuvenation capacity) are effective for frequent flood flows / flood event from Q2 to Q5)

# Propensity of channels to accumulate fine sediment: significance of trends



10 time-dependent channels ( $P < 0.05$ )

6 channels did not exhibit any significant time-dependent changes (*a priori* able to self-maintain their aquatic status over the long term)

# 2010's : Improvement and Sustainable development

1st Plan Rhône  
2007-2013

2nd Plan Rhône  
2015-2020

1982  
Cartogr  
polythématique

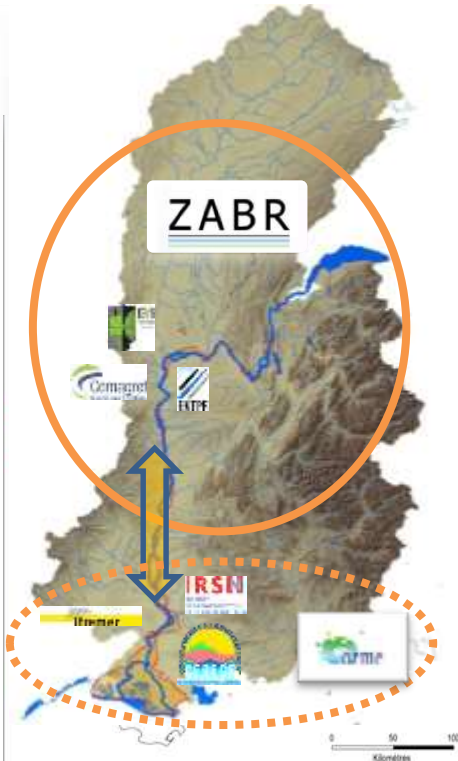
1990  
Assises  
nationales de  
l'eau

1993  
Fluvial  
hydrosystem

2001  
ZABR



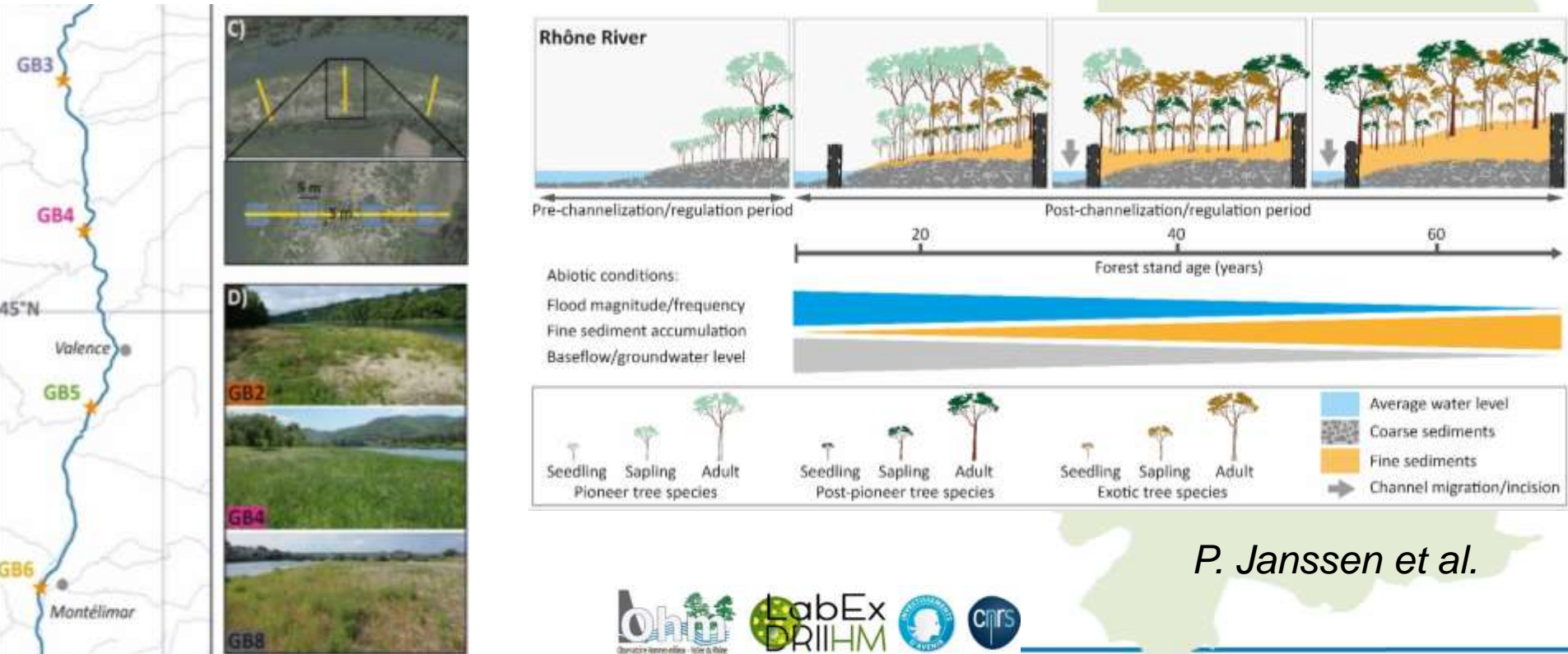
1982 RGL  
hydrosystème



- Historical trajectory of the Rhône
- Implementation of a sustainable development policy
- Hydrosystem functioning
- Environmental risks  
(Pollutants, Flooding, Climate change and water availability)
- **Restoration**
- New tools
  - 160 researchers (50 ETP)
  - 2 full time research managers

# Considering process-based restoration

- 2003 floods => channel widening to manage flood risk
- Remove bank protections to manage flood risk and improve ecological conditions... « And/and » or « or »?



*P. Janssen et al.*

# New restoration perspectives



## Possible solutions

- Redynamisation of channel margins based on bank protection removal
- Redynamisation of the channel based on gravel augmentation or bank re-erosion
- Complementary solutions (dam transparency to sediment flux, master plan of sediment management)

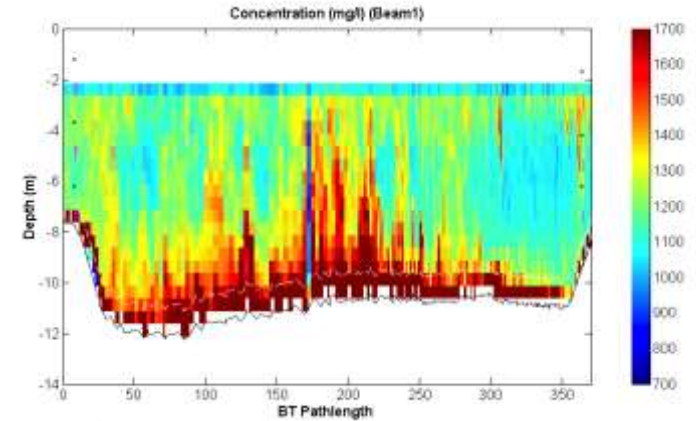


# Evaluate the bedload transfer: sand and pebbles

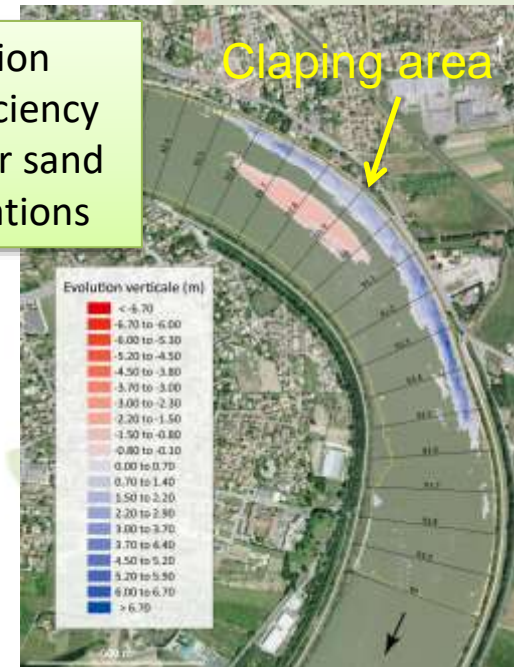
Development of technics to quantify and understand the bedload transfer



SPM extracted from ADCP signal



Evaluation of the efficiency of gravel or sand augmentations

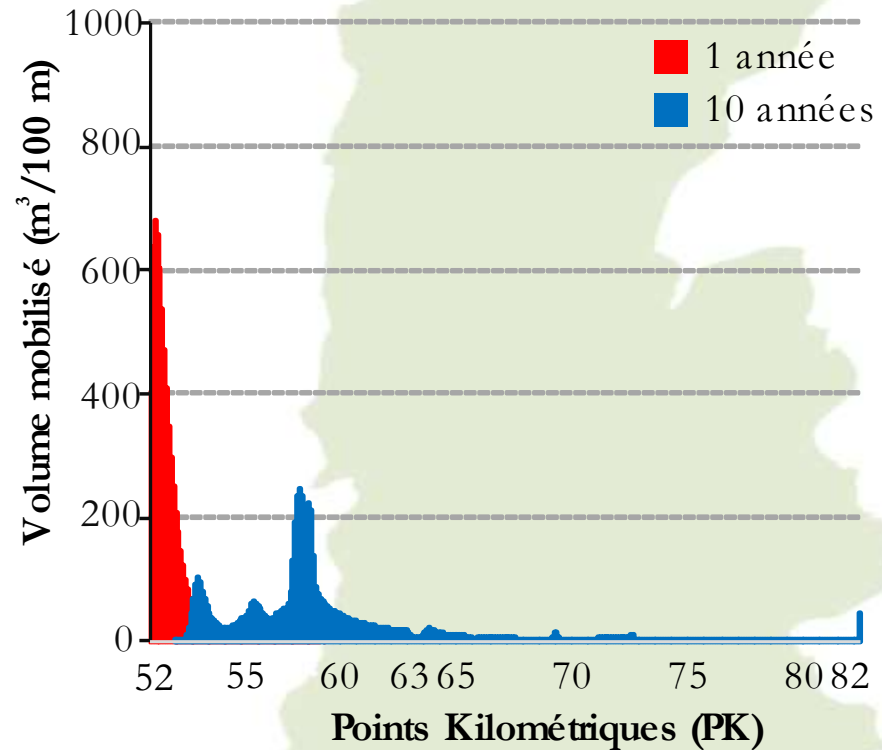
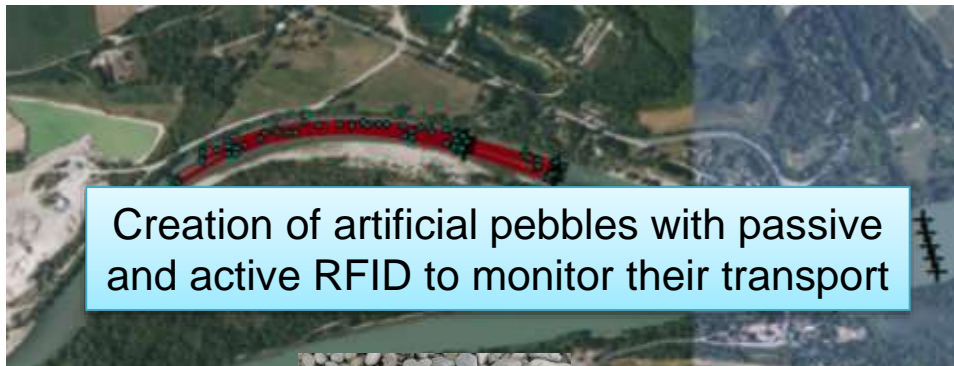


# Evaluate the transport capacity, the time needed for injected sediment to pass through a by-passed reach

Rate of detection: 70% downst. dam  
0% upstream dam.

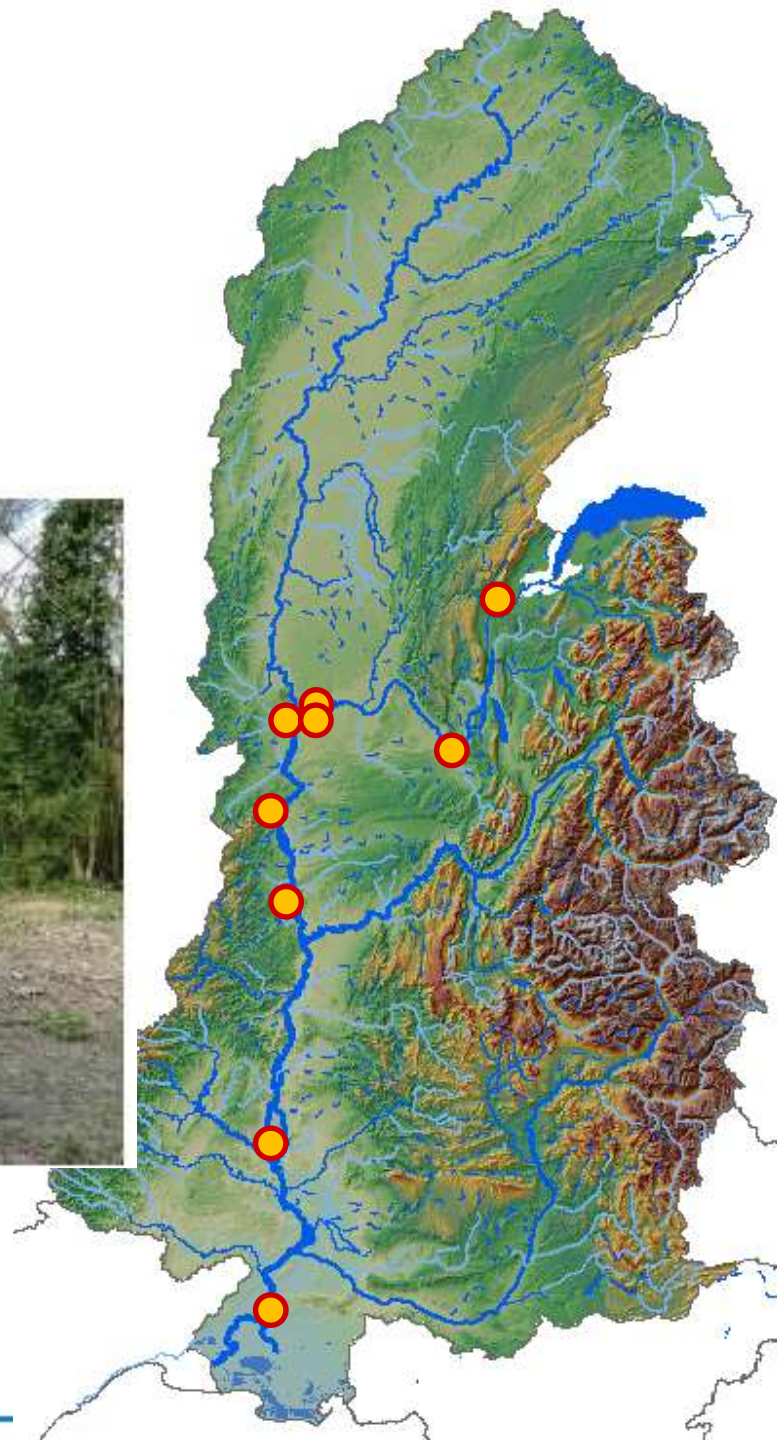
Dist. max  $\approx$  1060 metres

Dist. moyenne = 323 metres

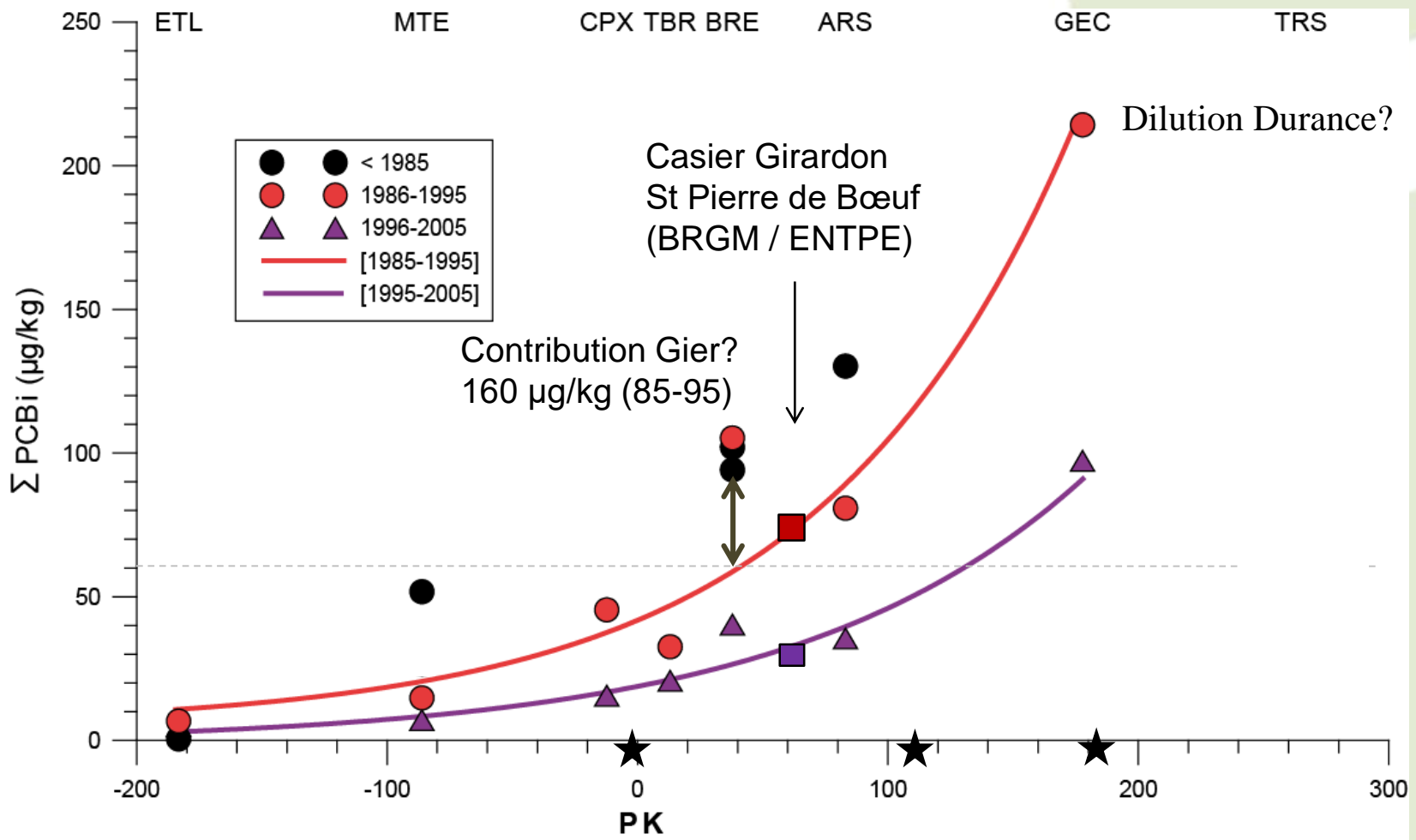


Vázquez-Tarrío et al.



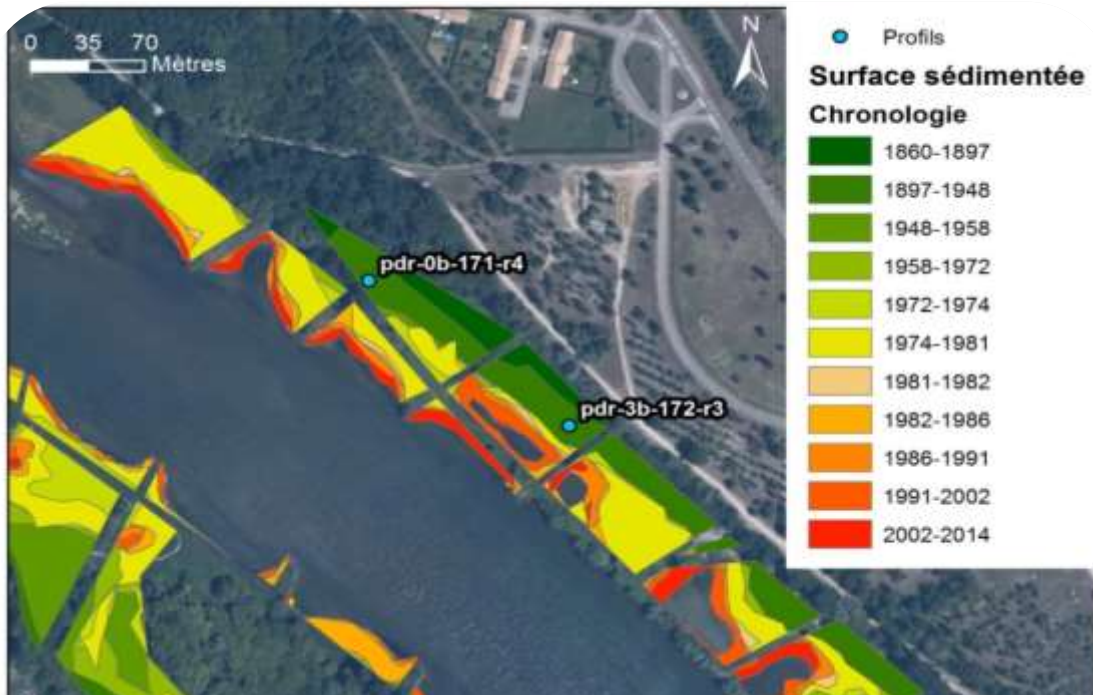




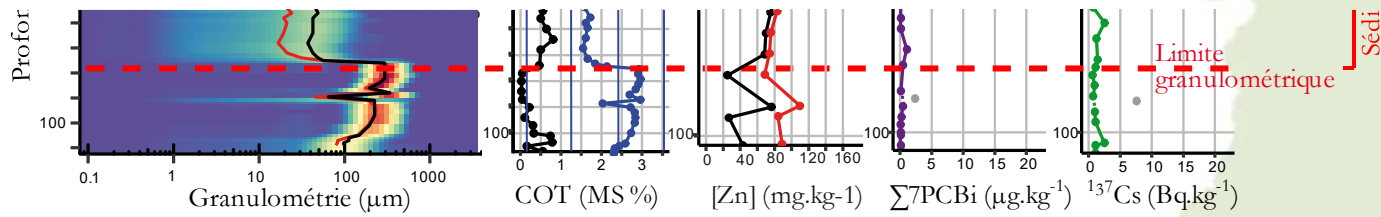


Geneva

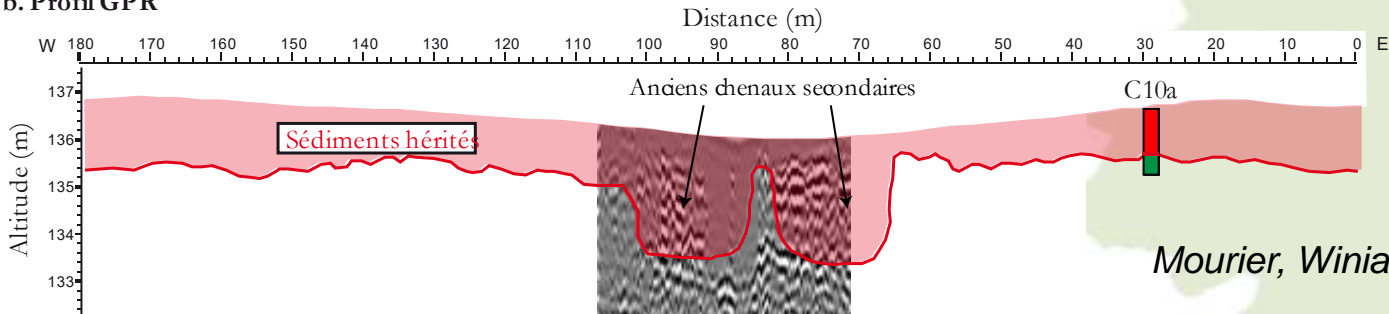
Delta



*Tena, Seignemartin, et al.*



**b. Profil GPR**



*Mourier, Winiarski et al.*

# Some conclusions

- Restoration is a long story on the Rhône (1990s)
- It is a dynamic and adaptive process
  - Habitat restoration
  - Process-based restoration
- Really need to have a good diagnosis
  - What are the problems?
  - What are the restoration options? Why?
- Monitoring provides key-feedbacks about
  - Success and failure
  - ... And models for pre-assessment
- Continuous exchanges between practitioners and scientists => long term observatory
  - To have a common platform to discuss
  - To accelerate knowledge transfers



# A collective adventure we want to share and discuss!

- Nicolas Lamouroux, Laurent Simon, Anne Clemens ZABR
  - Carole Barthelemy, HP
  - Olivier Radakowitch, Dad Roux, HP
  - Jean-Michel Olivier, NL
  - Christophe Douady, Sylvie Barraud, HP
- + 150 colleagues, post-docs,  
PhDs, Masters, technical staff...



School of  
integrated  
water sciences





# Thank you for your attention



Rhône-Alpes



GRAND LYON



ZABR

