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# Multi-site comparison of gravel travel distance by RFID tracking in large rivers: methodological and practical feedback

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## I. Context and objectives

The hydro-sedimentary processes of the Rhône River have been severely altered by human activities since the 19th century (i.e., incision, armoring, sediment supply interruption). Several restoration actions have been implemented to mitigate the physical effect (i.e., gravel augmentation, groyne fields removal to promote bank re-erosion and sediment supply).



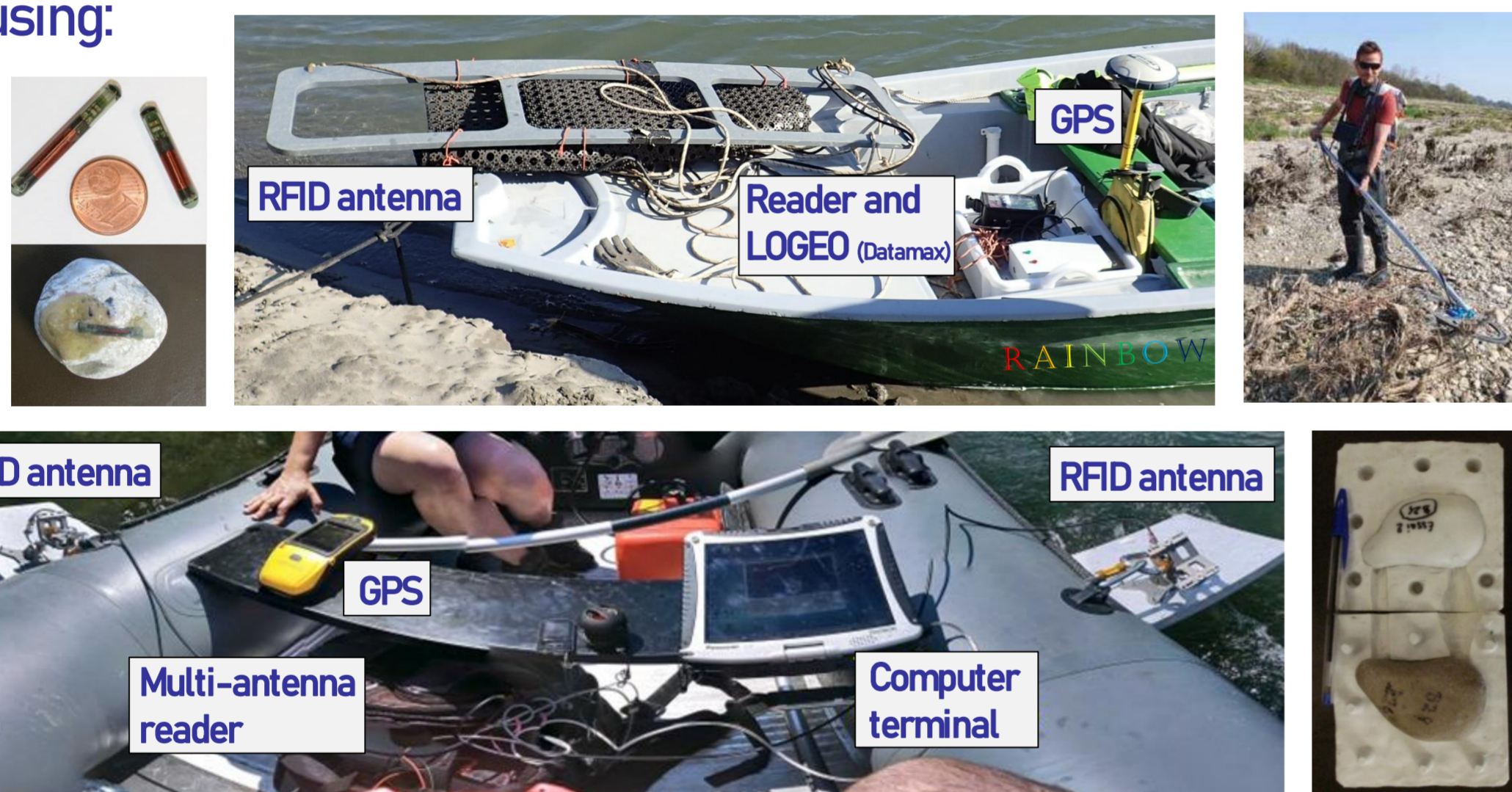
Objectives of this study:

- measuring gravel displacement by RFID particle tracking in a multi-site context (which differ according to their natural setting and human impacts)
- monitoring and evaluating the restoration projects

## III. Material & methods

RFID particle tracking using:

- PIT tags
- a-UHF tags



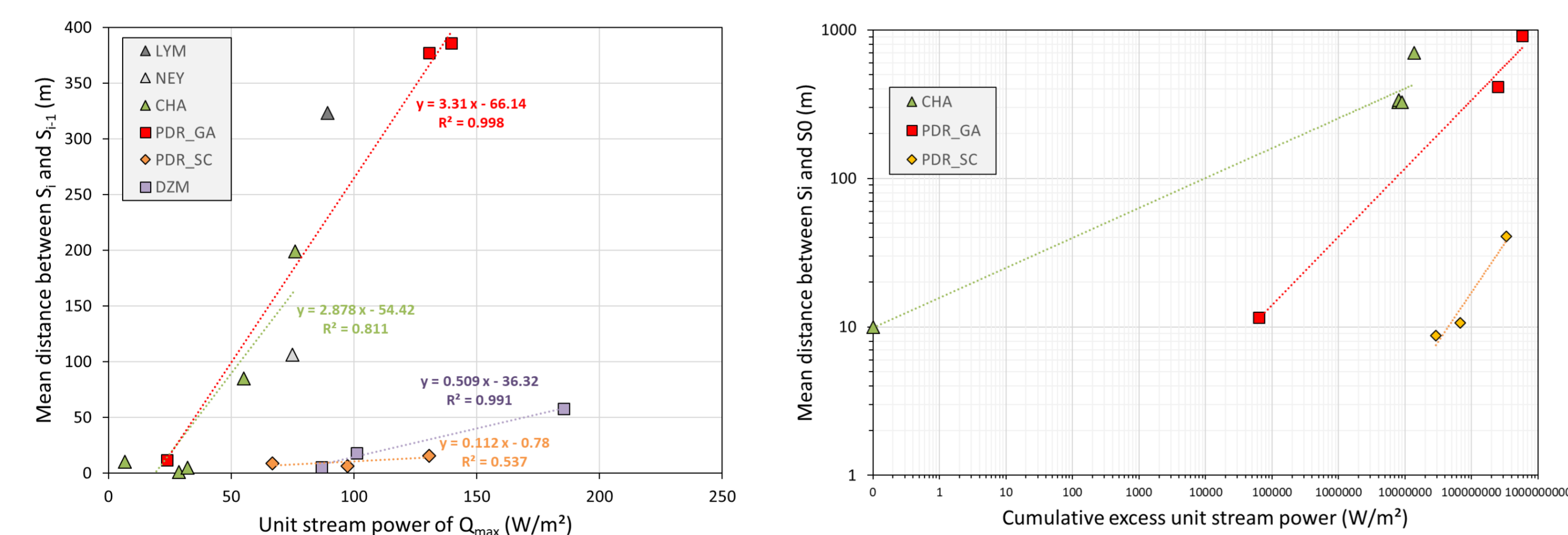
Cassel et al., 2017

Calculation of:

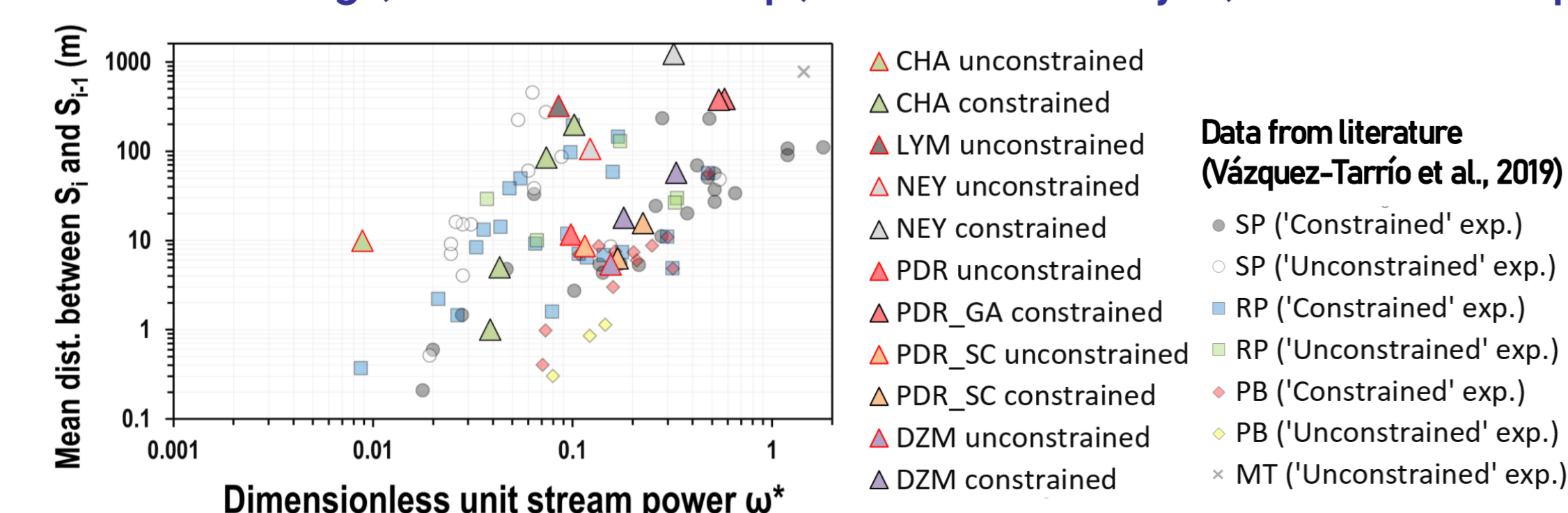
- travel distances (mean, max. + four grain size classes) between individual tracers found:
  - in two successive surveys ( $S_{i-1}$  and  $S_i$ );
  - in a given survey ( $S_i$ ) compared with the initial tracer seeding position ( $S_0$ );
- virtual velocity
- flow metrics:
  - unit stream power ( $\omega$ ; Bagnold, 1977)
  - Cumulative excess stream power ( $\Sigma(\omega_t - \omega_c)$ ; Hassan et al., 1992)
  - dimensionless unit stream power ( $\omega^*$ ; Eaton & Church, 2011)

## V. Reach comparison

Travel distances are higher in dynamic reaches (LYM, NEY, CHA) than in sediment-starved reaches (PDR\_GA, PDR\_SC, DZM)



Mobility is also controlled by particle arrangement and bed texture: 1<sup>st</sup> survey after tracer seeding (unconstrained exp.) vs. other surveys (constrained exp.)

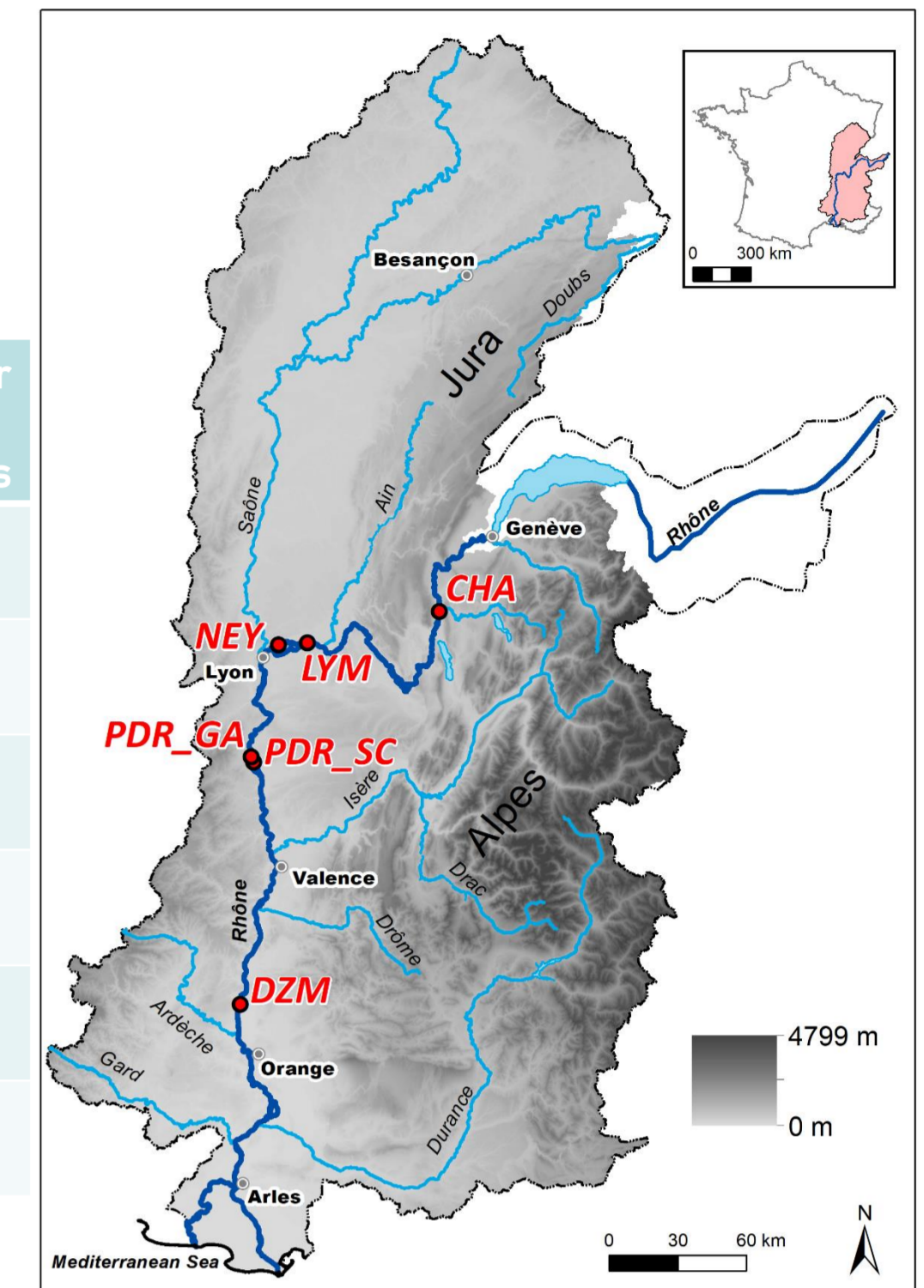


Bagnold, R. A., 1977. Bed load transport by natural rivers, Water Resour. Res. 13(2), 303-312  
 Cassel M., Dépret T., Piégay H., 2017. Assessment of a new solution for tracking pebbles in rivers based on active RFID. Earth Surf. Process. Landforms 42: 1938-1951  
 Eaton B., Church M., 2011. A rational sediment transport scaling relation based on dimensionless stream power. Earth Surf. Process. Landforms 36(7), 901-910.  
 Hassan M.A., Church M., Ashworth P.J., 1992. Virtual rate and mean distance of travel of individual clasts in gravel-bed channels. Earth Surf. Process. Landforms 17(6), 617-627.

## II. Study sites

6 study sites located along bypassed channel of 4 diversion dam systems

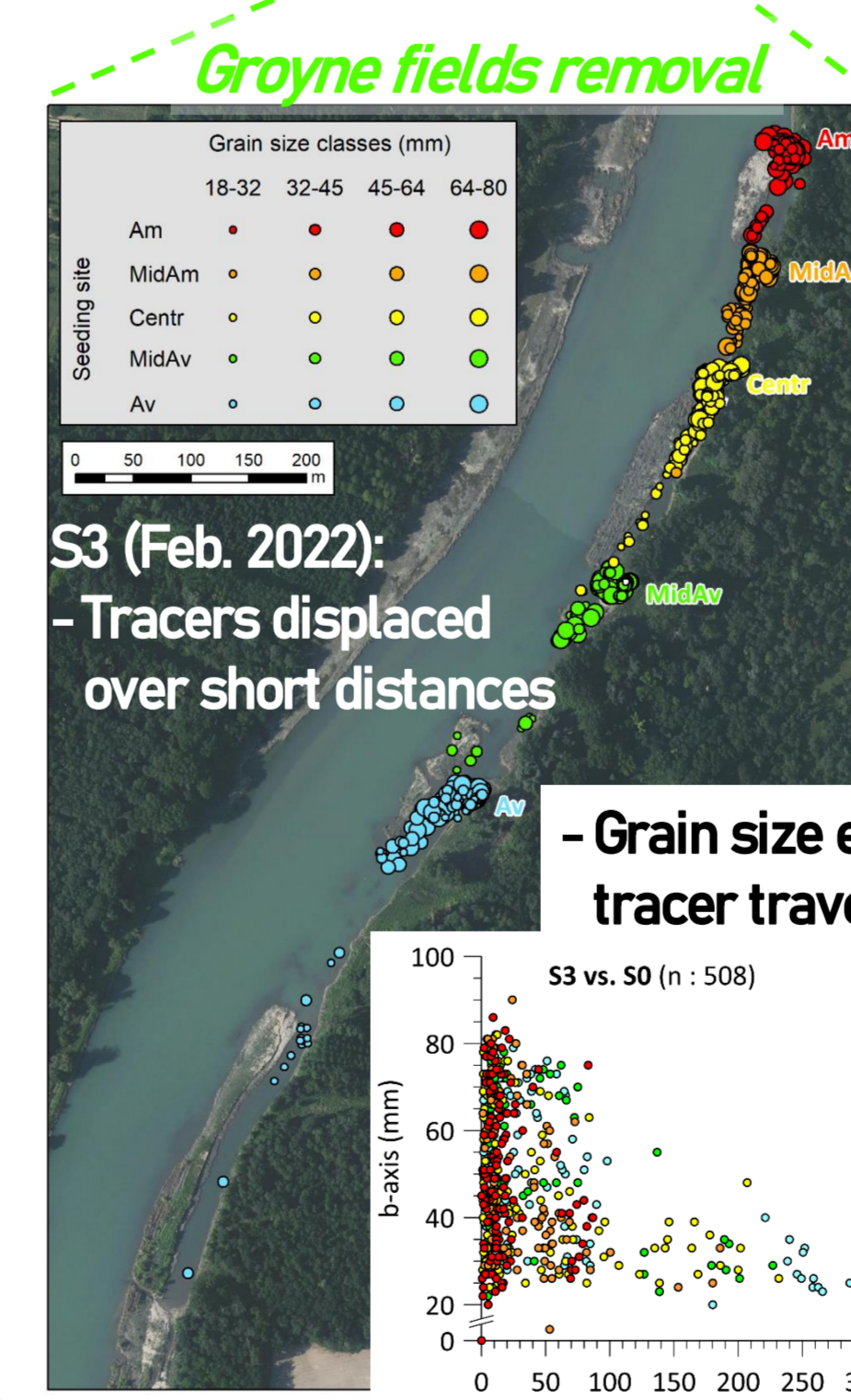
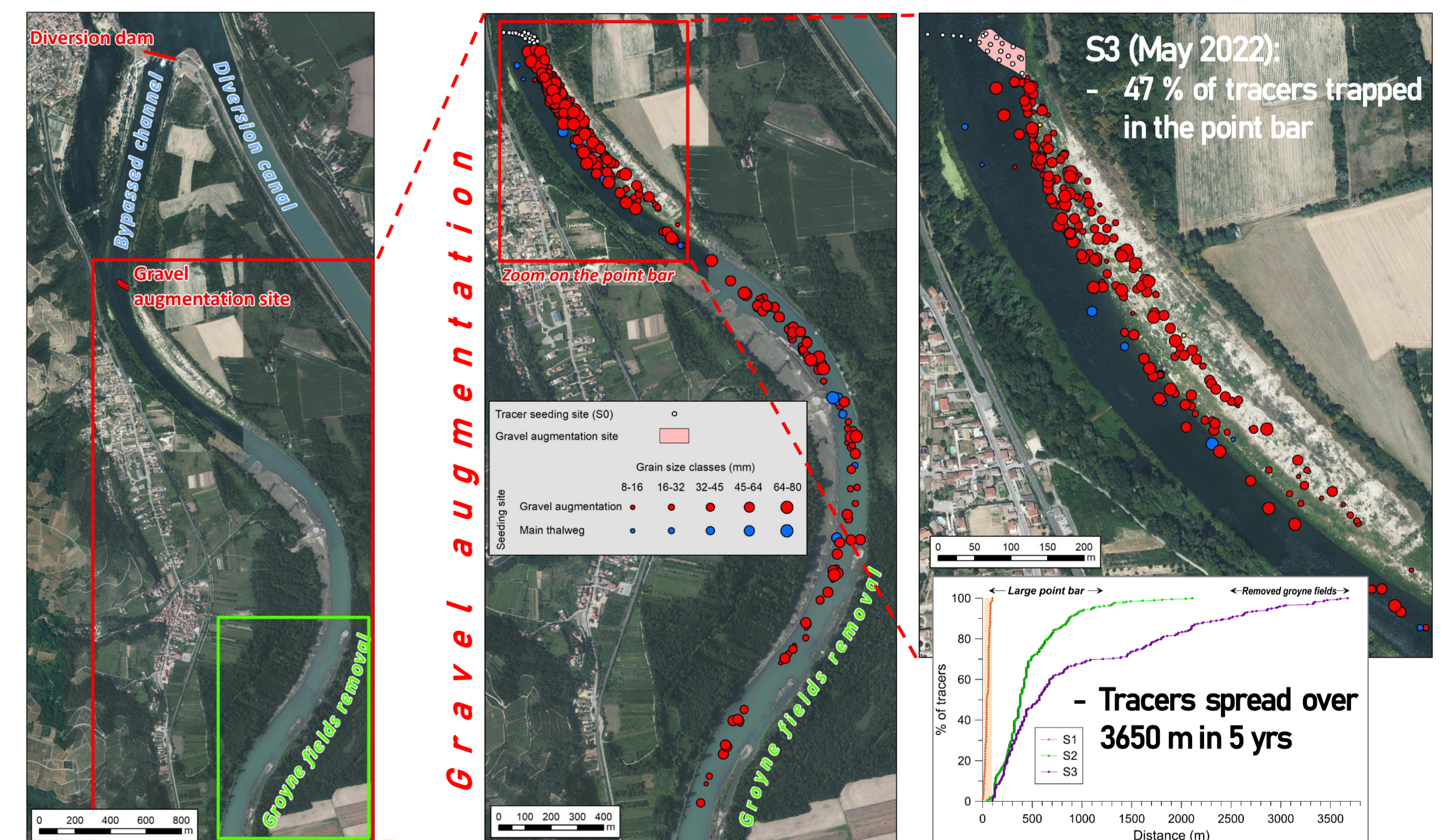
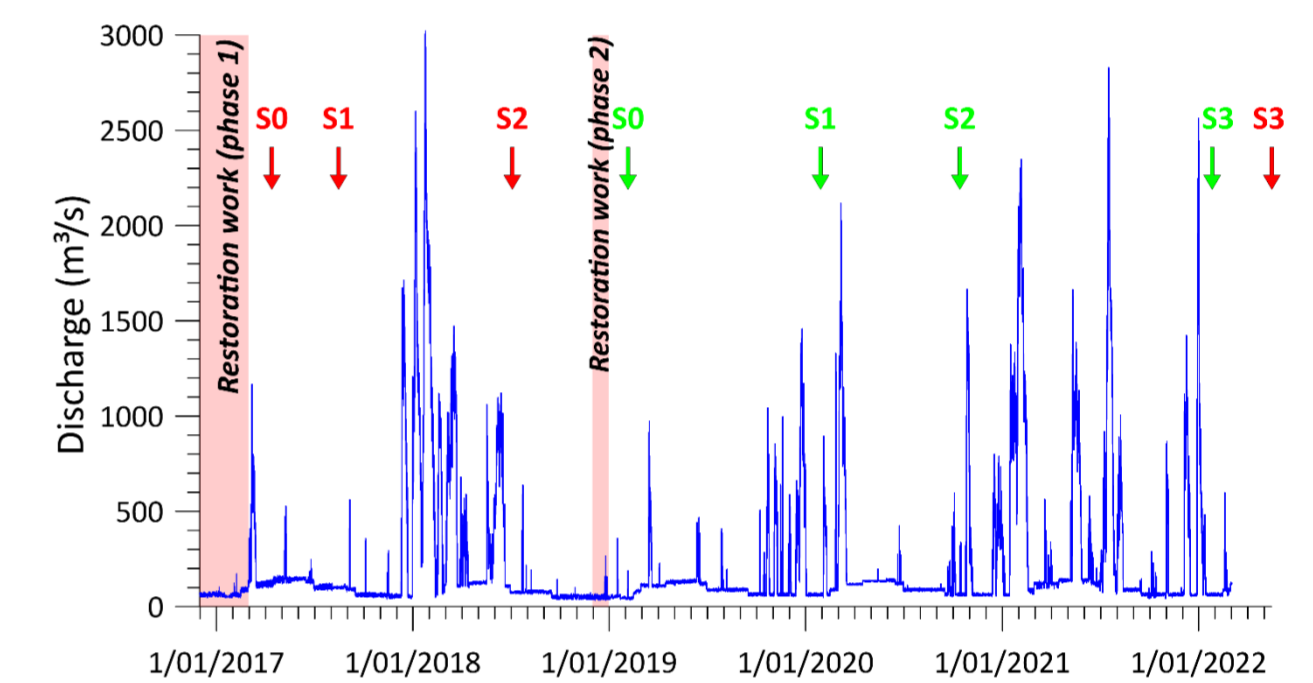
Site	Issue	Type of RFID	Date of tracer seeding (+ number of tracers)	Number of surveys
CHA	Gravel augmentation (15000 m <sup>3</sup> ) in a reach being starved of sediment	PIT tags 23/32 mm	Dec. 2016 (888)	5
LYM	Evaluation of bedload transport (reference reach) and continuity	a-UHF tags: COIN-HC	Oct. 2016 (200) August 2020 (199)	2 2
NEY	Evaluation of bedload transport (reference reach)	a-UHF tags: COIN-ID	January 2017 (100)	2
PDR_GA	Gravel augmentation (6885 m <sup>3</sup> ) in a sediment-starved reach	PIT tags 12/23/32 mm	March 2017 (991)	3
PDR_SC	Groyne fields removal in a sediment-starved reach	PIT tags 23/32 mm	February 2019 (999)	3
DZM	Gravel augmentation (30000 m <sup>3</sup> ) in a sediment-starved reach	PIT tags 23/32 mm	April 2019 (1199)	5



## IV. Example of PDR : 2 sites, 3 surveys

2 tracer seeding sites:

- 991 tracers in the gravel augmentation site (GA), including 100 tracers around the augmentation site
- 999 tracers in the side channel (SC) formed by the removal of groyne fields



Comparison of local virtual velocities shows major disparities between the different parts of the channel

	S3 vs. S0	GA (thalweg + point bar)	GA (thalweg)	GA (point bar)	SC (groyne fields removal)
Period length (yrs)	5.1	5.1	5.1	5.1	3
Time $Q > Q_c$ (h)	6012	6012	6012	6012	3603
$Q_{max}$ (m <sup>3</sup> /s)	3021	3021	3021	3021	2828
Number of recovered tracers	317	169	148	148	508
Number of mobile tracers	317	169	148	148	244
% of mobile tracers	100	100	100	100	48
Mean distance between S3 and S0 (m)	915	1395	373	373	41
Virtual velocity (m/h)	0.15	0.23	0.06	0.06	0.01
Max distance (m)	3652	3652	966	966	475

## VI. Outcomes

This study provides a better understanding of bedload transport in the Rhône River and highlights its specific features according to the natural setting and human impacts. It also provides:

- useful information for evaluating the success of restoration projects
- recommendations for designing gravel augmentation projects in terms of site selection (sites with sufficient shear stress; not upstream of point bars), volume of gravel (1-2 X the mean annual bedload transport capacity), etc.
- methodological feedback for applying such technique in a large non-wadable rivers (i.e., decrease in recovery rates over time, suitability of tracer types and sizes)