Université François Rabelais de Tours,
CNRS/INSU - UMR 6113
CETU Elmis

Influence of dam removal and past sediment mining on river morphology and biology: example of the Vienne River (France)

S. Rodrigues, N. Richard, P. Juge, J. Berthomé, G. Cochet, J.R. Malavoi

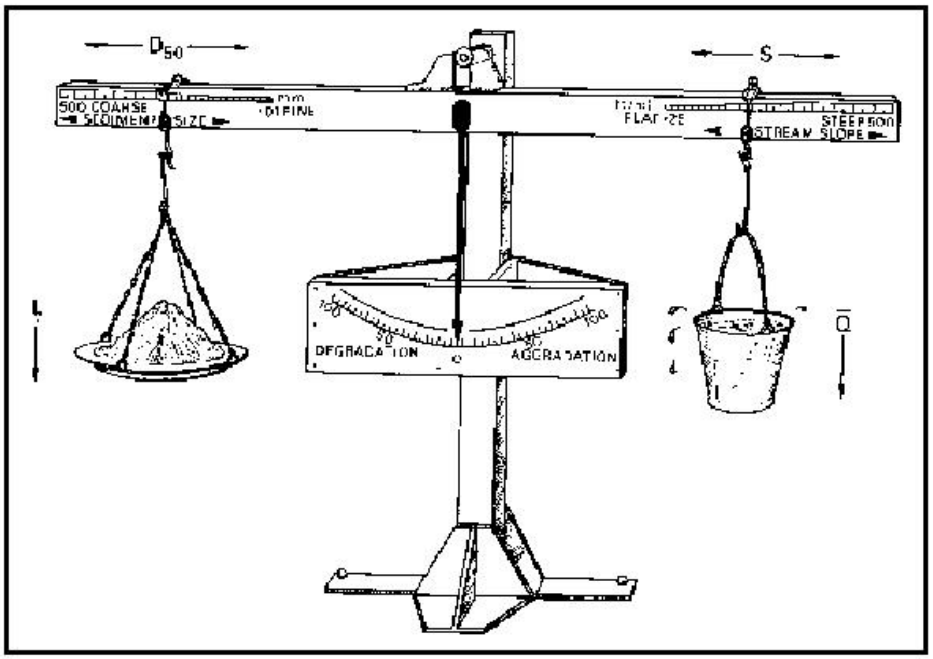
Context

Due to the Water Framework Directive, dam removal is going on in France

Free migration of sediments and fish

Space and mobility for rivers

Morphological equilibrium



Lane's Balance (after E. W. Lane, from W. Borland)

River incision problems

Masterplan « Plan Loire Grandeur Nature III »

comité de bassin Loire-Bretagne

PLAN LOIRE GRANDEUR NATURE

l'Europe s'engage dans le bassin de la Loire avec le FEDER

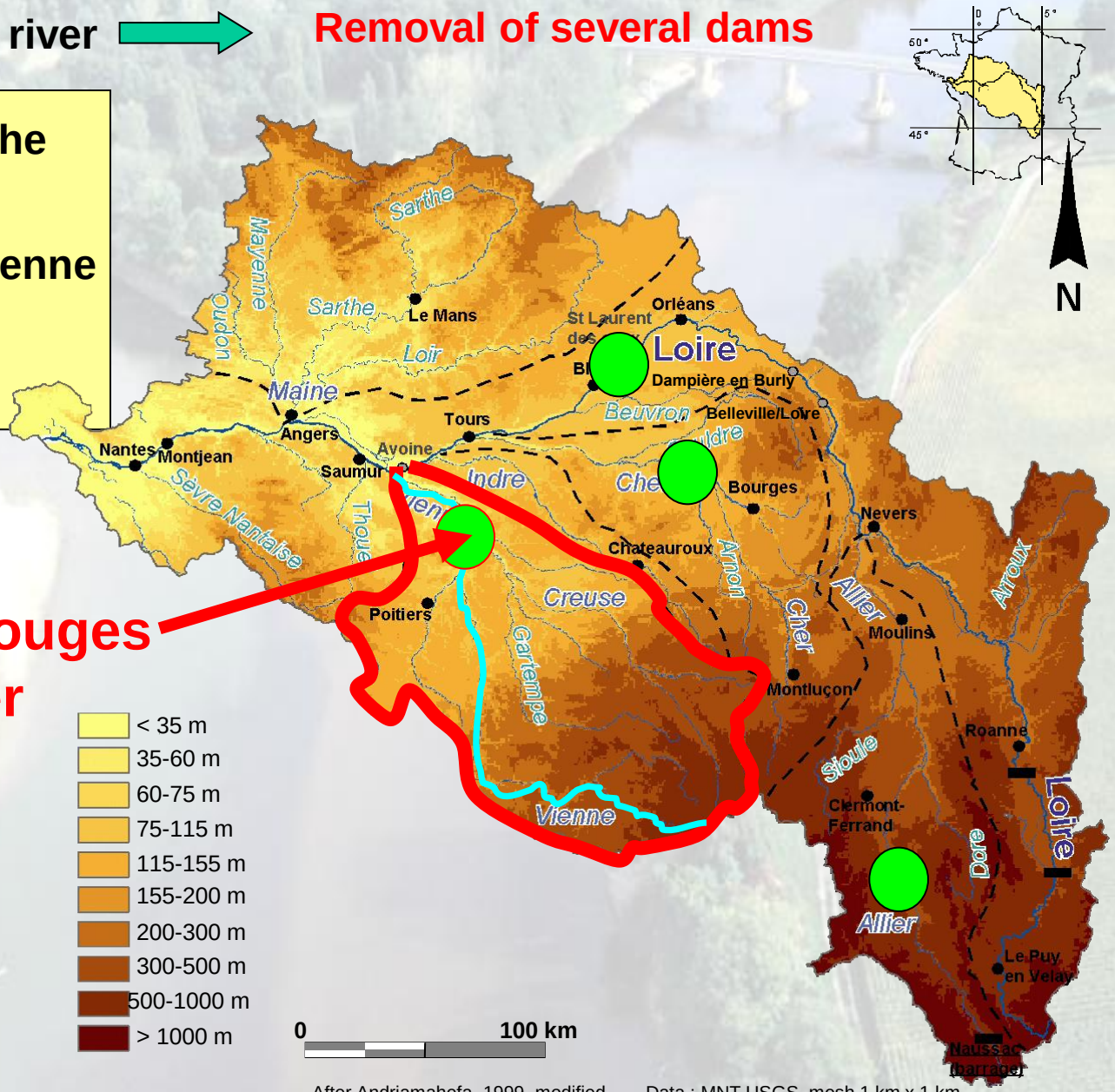
Context and study site

Loire River: larger french river → **Removal of several dams**

A tributary of the Loire: the Vienne River

Catchment area of the Vienne River: 21 000 km²

Stream length 370 km



Dam of Maisons Rouges on the Vienne River (removed in 1999)

Dams removed

After Andriamahefa, 1999, modified.

Data : MNT USGS, mesh 1 km x 1 km

REMOVAL OF MAISONS-ROUGES' DAM

Questions, goals and approach

Questions

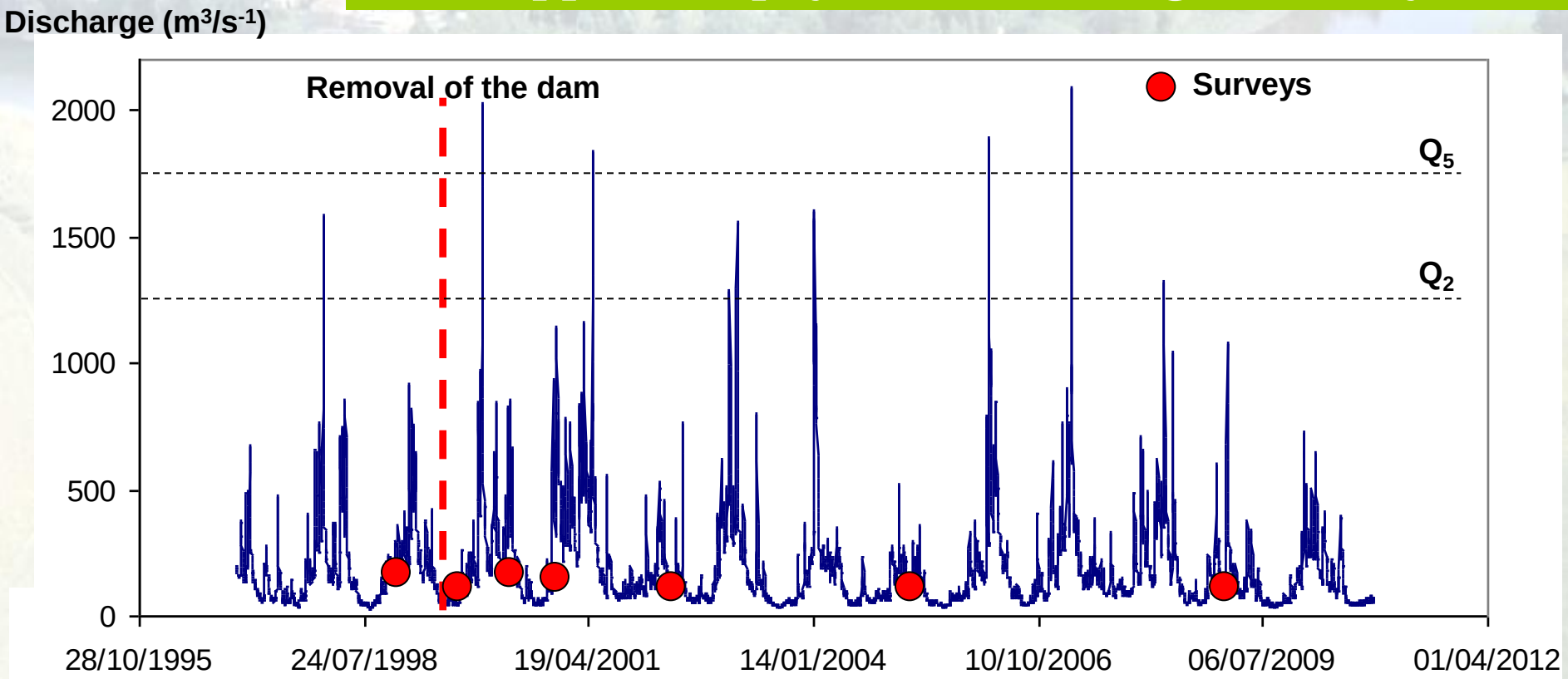
- **Ability of the river to flush the sediment downstream and restore a morphological equilibrium**
- **Influence on in-channel species in the dam and downstream (benthic macroinvertebrates, mussels…)**

Approach

10 years sedimentological and morphological survey

Analysis of habitat diversity and populations (vegetation, benthic macroinvertebrates, mussels)

Approach: physical and biological survey



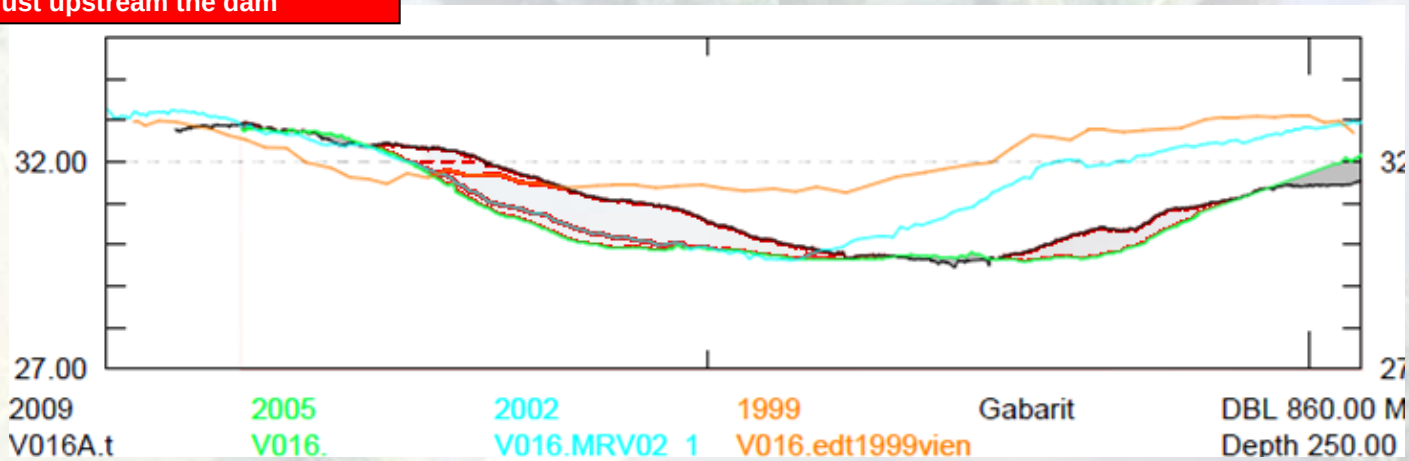
- **Bed topography in 1998, 1999, 2000 a and b, 2002, 2005, 2009 (226 cross sections; less than 200 m on average)**
- **Grain size analysis of bed sediments**
- **Aerial photographs (constant discharge)**
- **Analysis of vegetation, macroinvertebrates and mussels**

Sedimentological and morphological survey

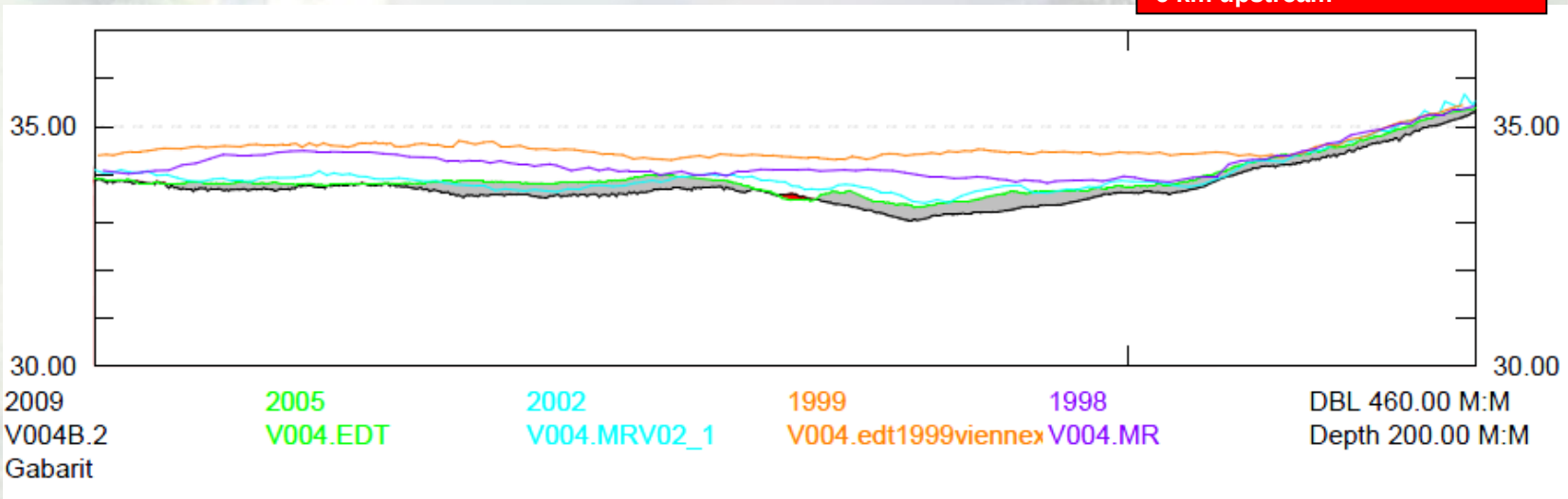
Results: downstream migration of sediment waves

- **Significant upstream scouring since dam removal**

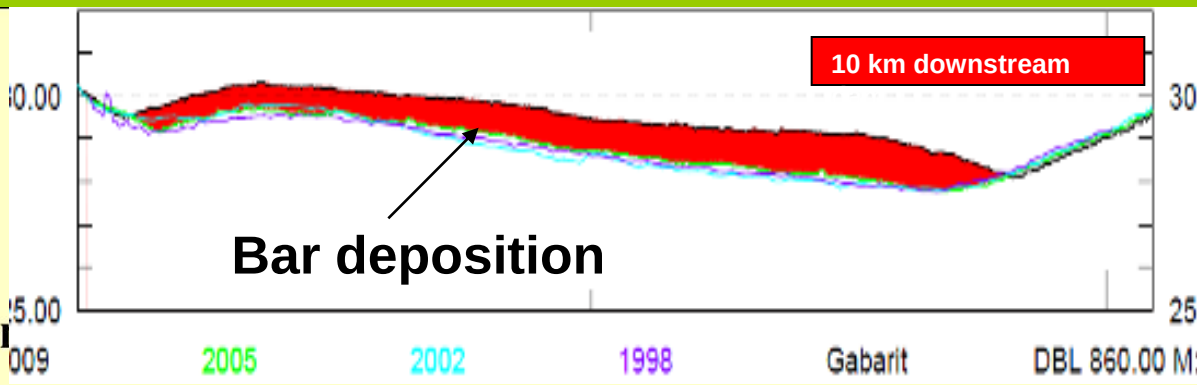
Just upstream the dam



6 km upstream

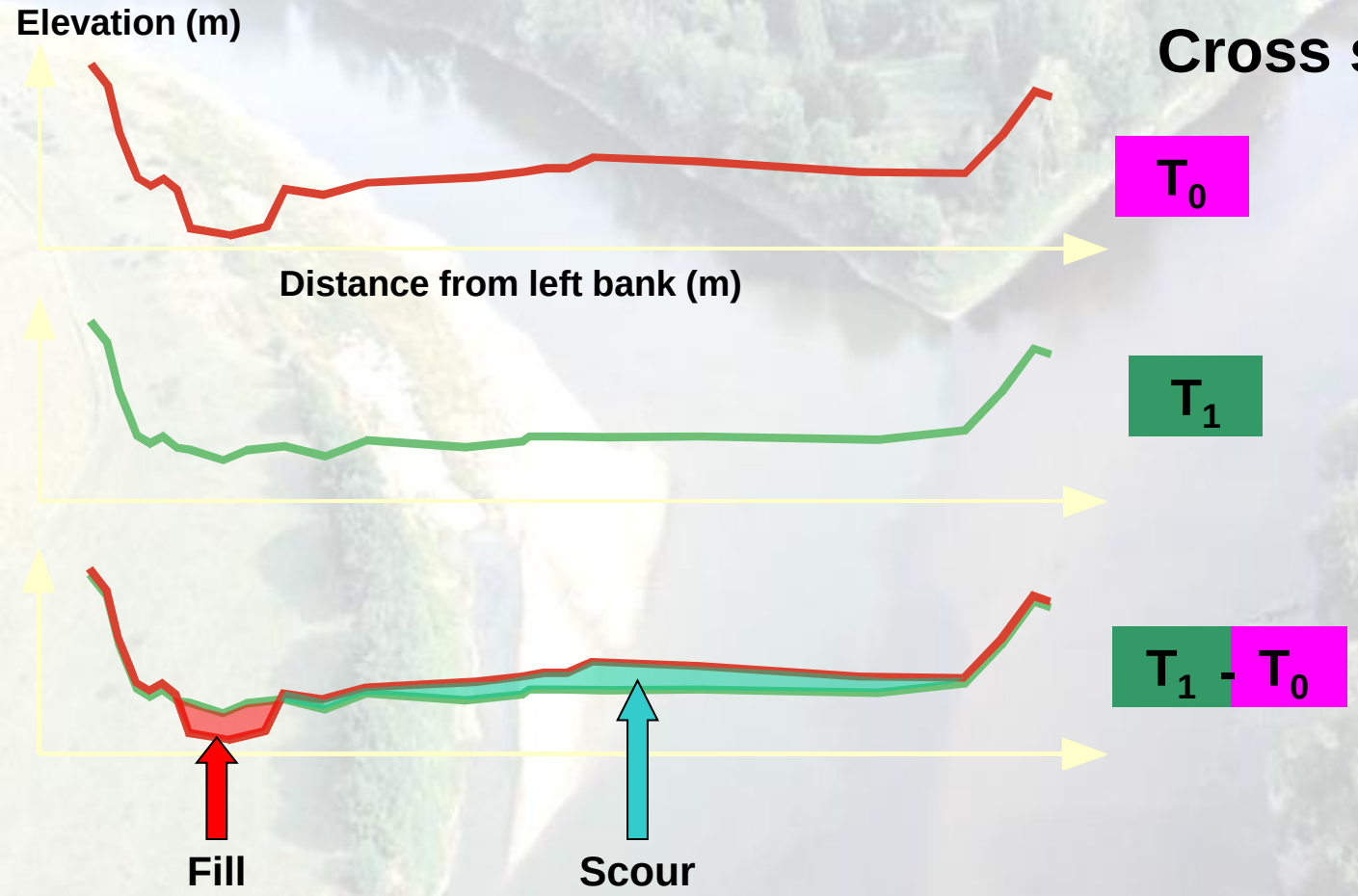


Results: downstream migration of sediment waves



Sediment deposition downstream the dam and migration of large bars at a velocity of 2.5 km/year

Results: sediment budgets between 2005 - 2009



Cross section analysis

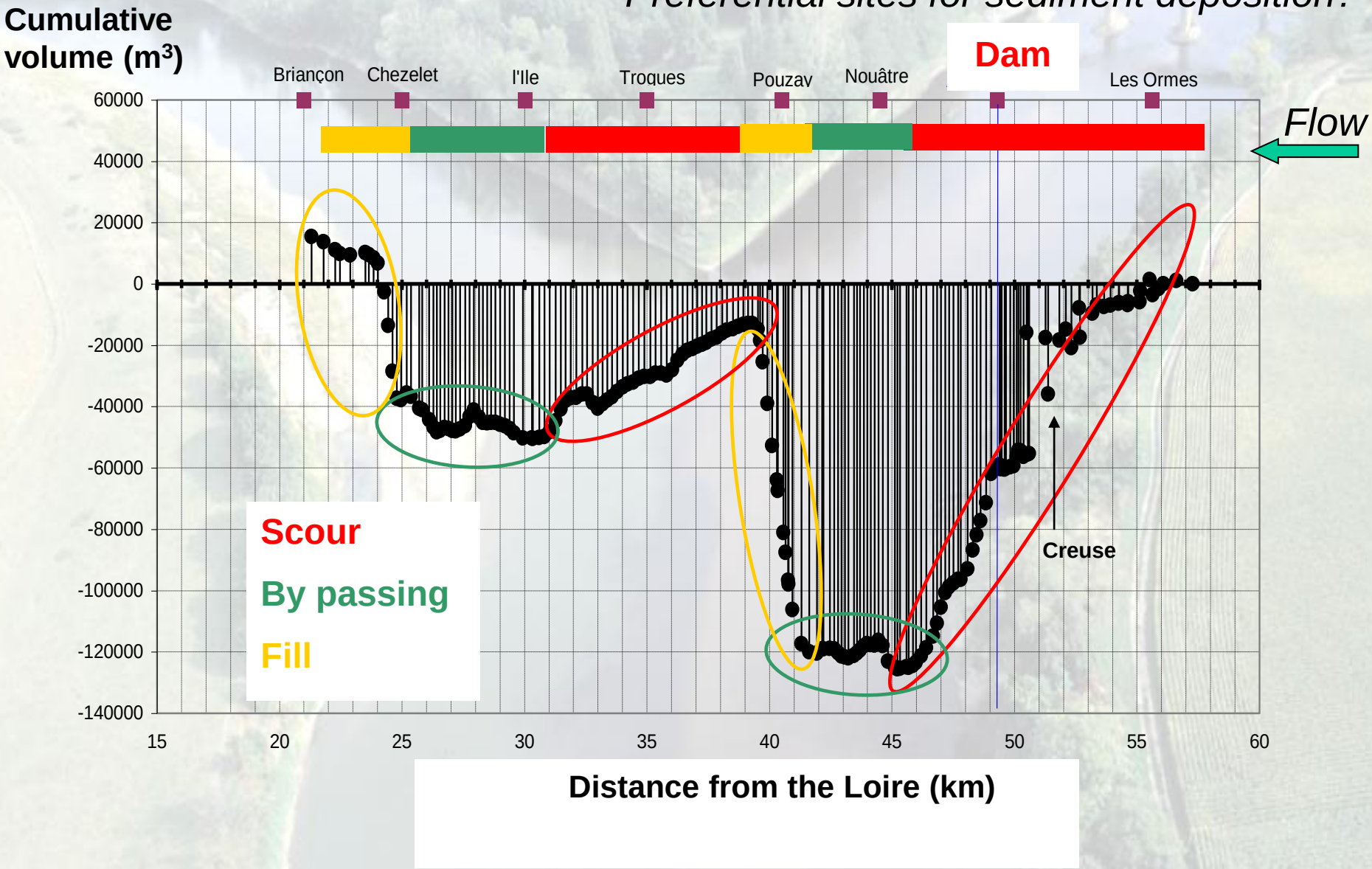
T_0

T_1

$T_1 - T_0$

Results: cumulative sediment budgets between 2005 - 2009

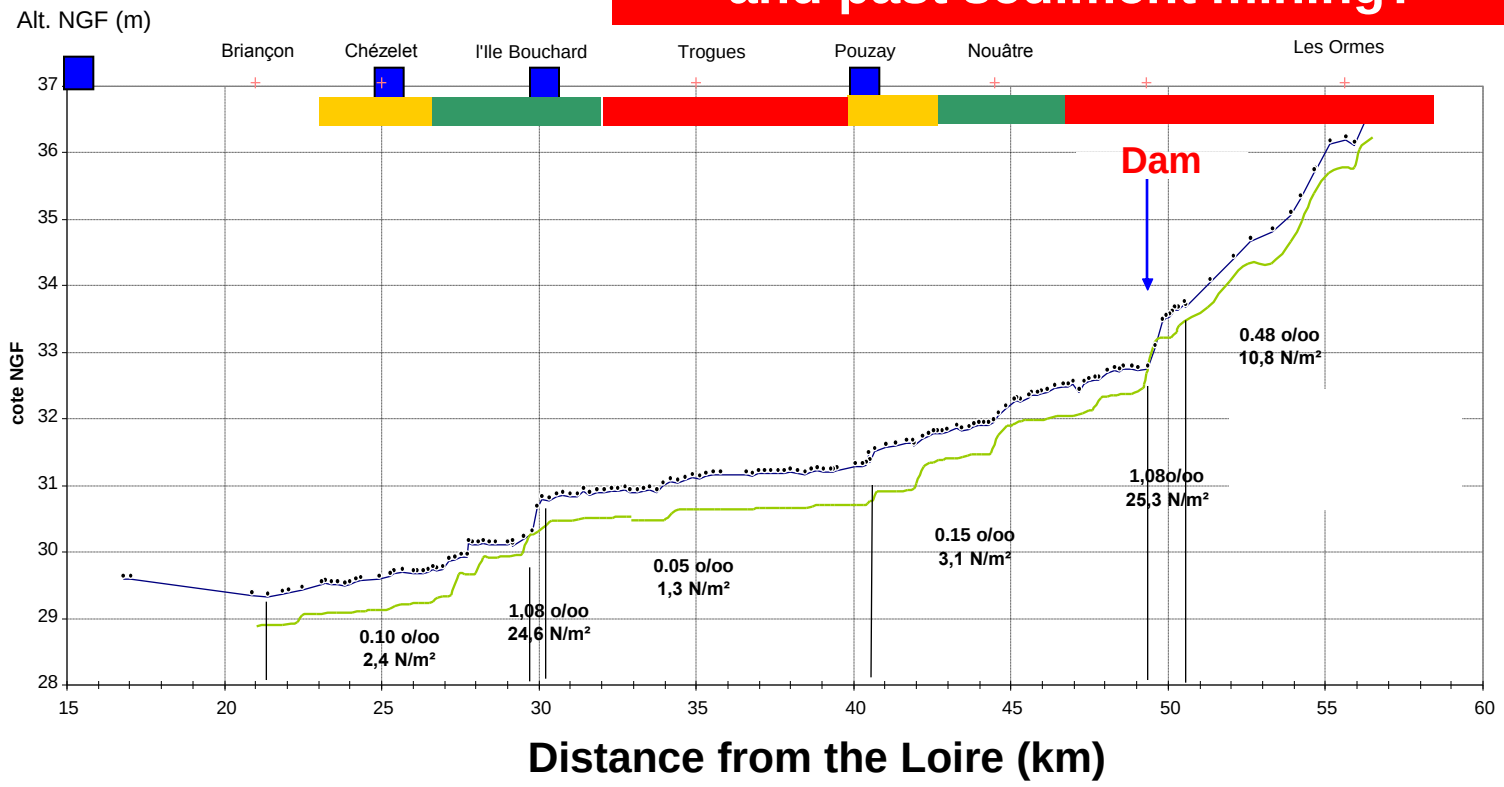
Preferential sites for sediment deposition?



Results: bed shear stress assessed from water levels

$$\tau_0 = \rho g R_h \sin\phi \quad (\sin\phi = \phi)$$

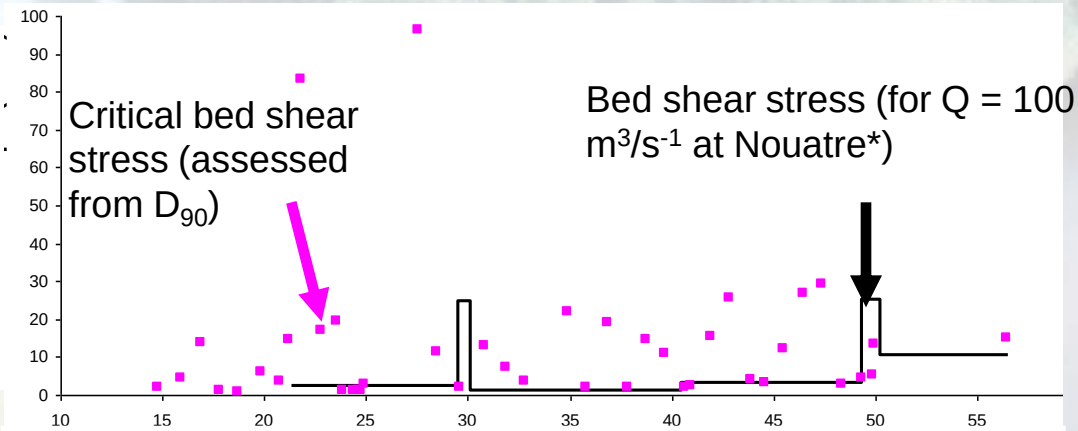
Combined effect of dam removal and past sediment mining?

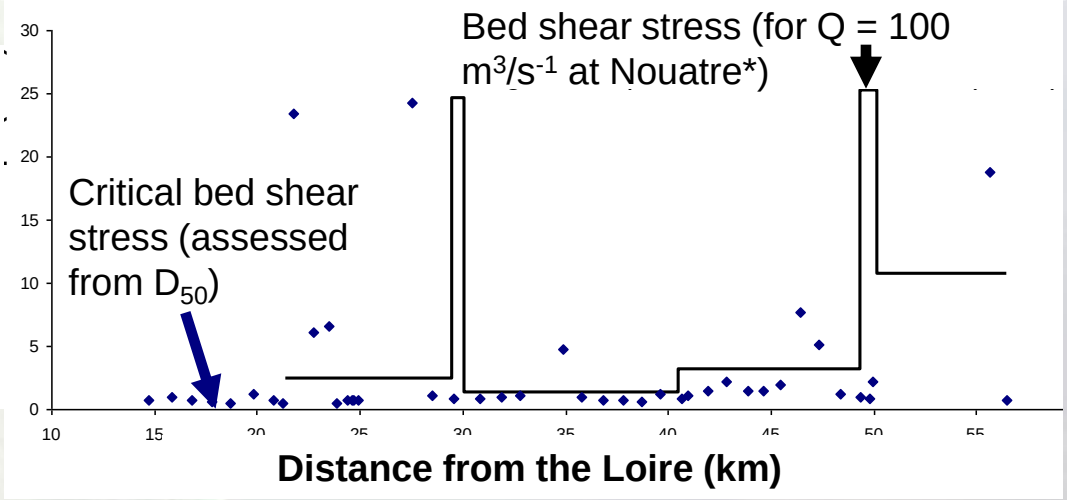


Scour By-passing Fill

Results: sediments mobility

Shear stress (N.m^{-2})



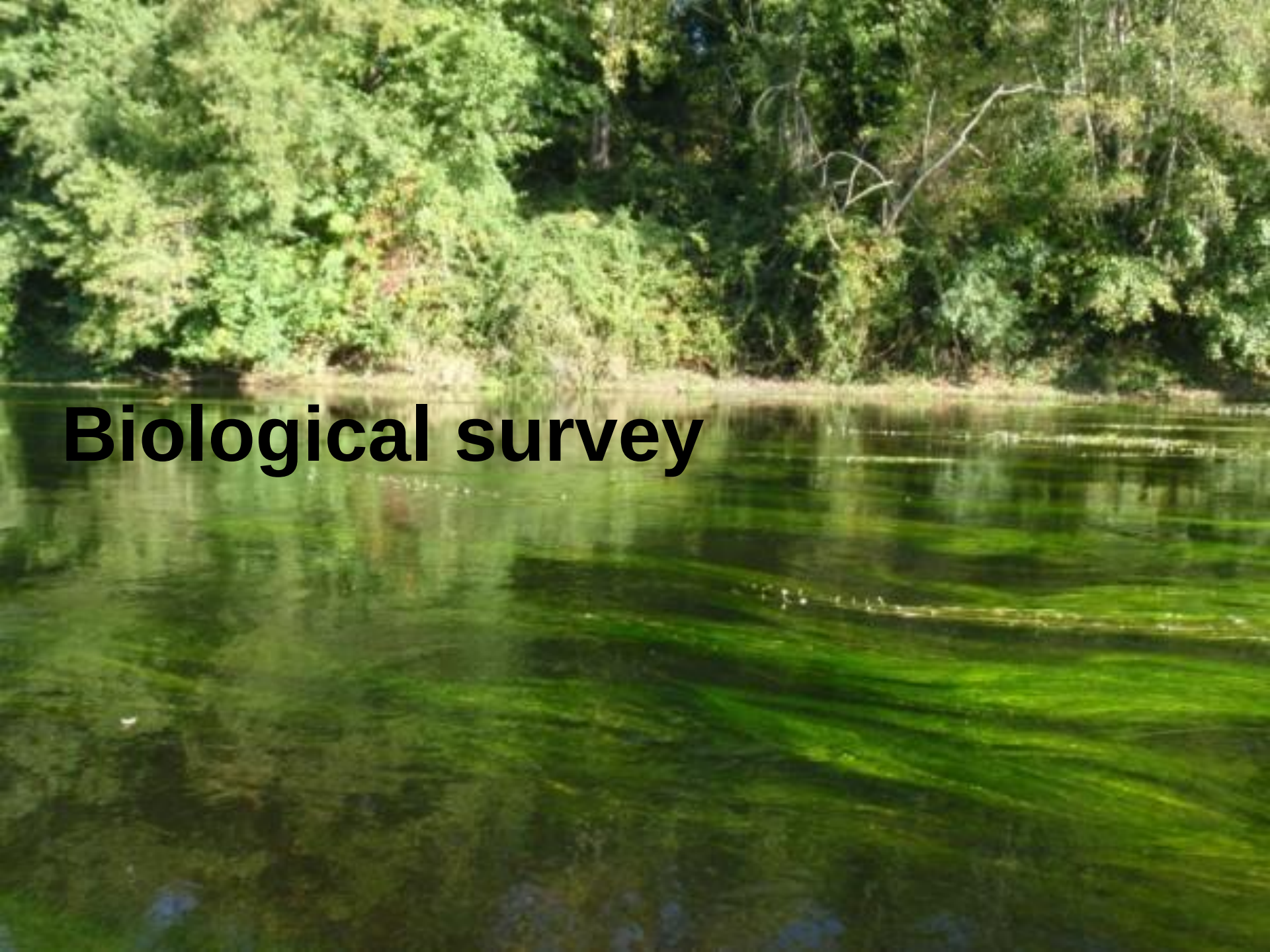


$$\theta_c = \frac{\tau_c}{(\rho s - \rho w) g.D} = fct\frac{u^*D}{\nu}$$

$$\theta = \frac{\text{Shear force}}{\text{Gravity force}}$$

Threshold of motion for a given grain size

*Q = 100 m^3/s^{-1} at Nouatre is reached 60% of time


Biological survey

Results: influence of dam removal on *Margaritifera auricularia*

Margaritifera auricularia

Length : 20 cm
Life duration : 150 years
Habitat : stabilized gravels

Status : protected by IUCN, protected in France,…

Rediscovered in the Vienne in 1998

Endangered specie

- Small and old populations (recruitment?),
- needs fish for reproduction (which ones?)
- sensitive to river degradation (fine sediments…)

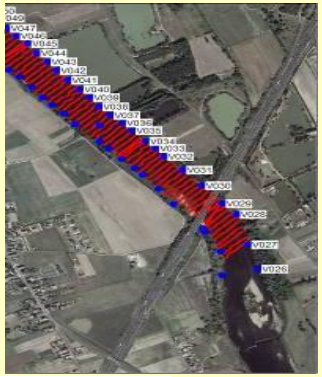
Were the populations of *Margaritifera auricularia* affected by the migration of bedload sediment waves coming from the dam?

Influence of dam removal on *Margaritifera auricularia*

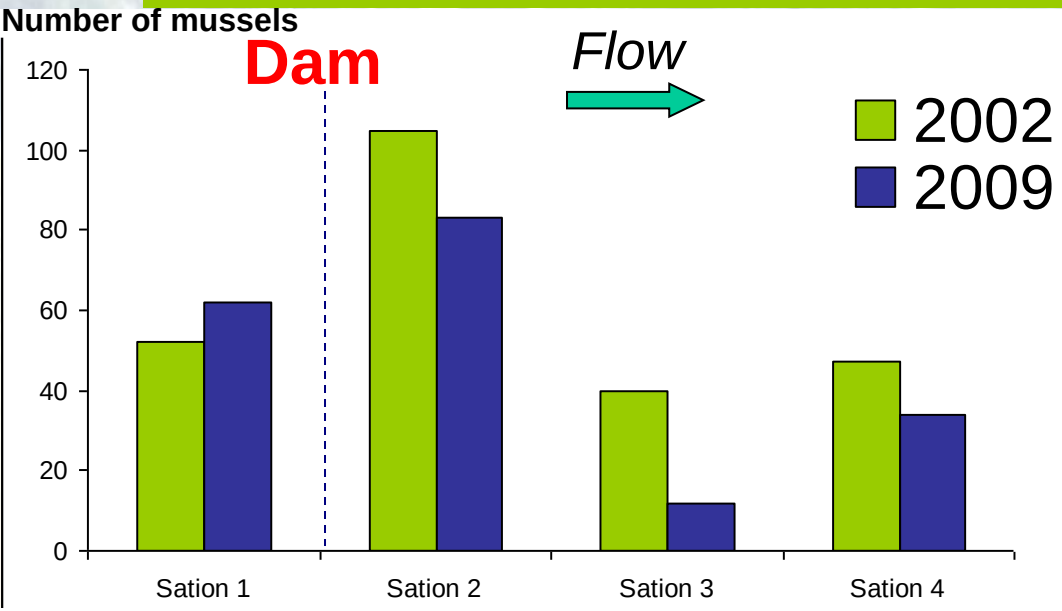
4 stations were surveyed

- Bed topography (cross sections spaced 10 m on average)

- geolocation GPS and tagging

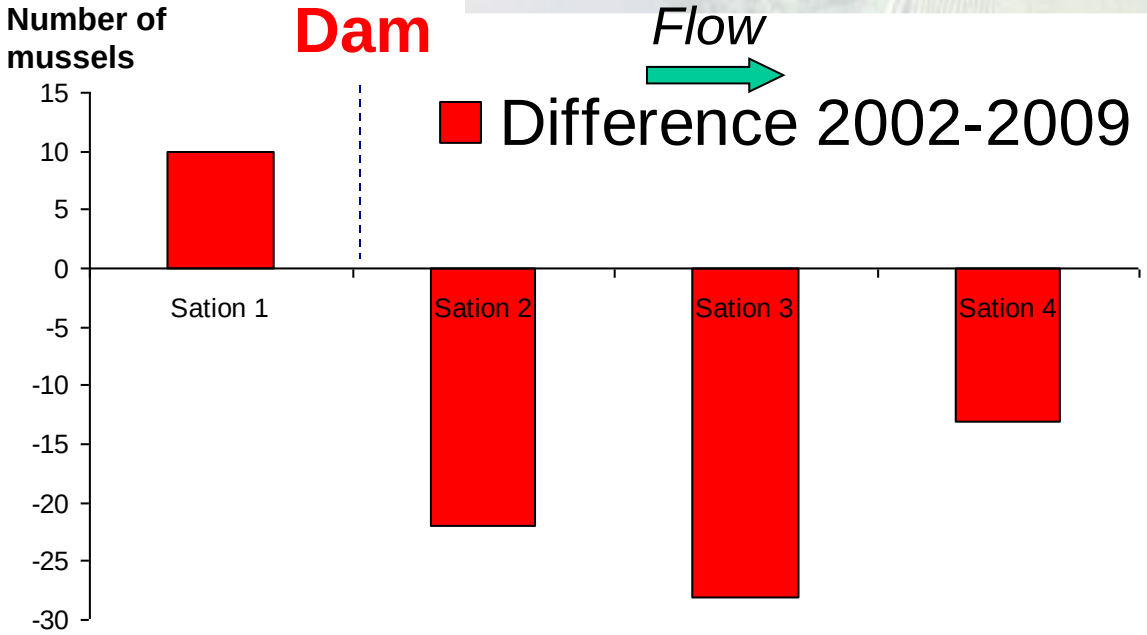


Results: influence of dam removal on *Margaritifera auricularia*



2002: 283 mussels

2009: more than 90 mussels disapeared (1/3 of the population)



Small increase upstream (habitat)

Significant decrease downstream

Conclusion *and Perspectives*

In 10 years, large bedload waves migrated 27 km downstream of the dam (celerity of 2.5 km/year)

Sediment trapping occured in the abandonned sediment mining sites

Detailled topographical surveys at past sediment mining sites

Regressive erosion is due to dam removal but also probably past sediment mining (stopped in 1998)

Study of bedrock outcrops and lateral migration of the river

Margaritifera auricularia **was found in the Vienne in 1998 but the populations are decreasing (excepted upstream of the dam).**

Topographical survey and tagging, influence of Petromyzon,…


Thank you for your attention

Results: bed shear stress assessed from water levels

Will the river incise its bed ?