Eco-hydrological impacts of hydropower production in the Adige river system

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- ✓In the Alps high precipitation and steep slopes are perfect pre-conditions for hydropower generation
- ✓Free domestic energy production reducing CO2 output
- ✓Important economic factor at regional scale
- ✓Quick response to energy demand
- ✓Ideal partner for other renewables and excess production from oil, coal and nuclear plants (via pump storage)

Furthermore:

- ✓EU obligations to meet Kioto targets
- ✓EU energy targets (20% renewables, 20 % increase in energy efficiency, 20% cut in green house gases)
- ✓Independence for imports

But traditional production schemes have severe impacts on freshwater ecosystems and related benefits and goods, which have considerable environmental, social and economic relevance

Challenges for the future

- ✓ **Proper implementation of the Alpine Convention protocols (Energy and other)**
- ✓ **Proper implementation of the EU WFD 2000/60 EC**

In Alpine streams hydropower production alters the natural flow in the three phases of production

Reduced and constant discharge

Winter freezing, summer heating

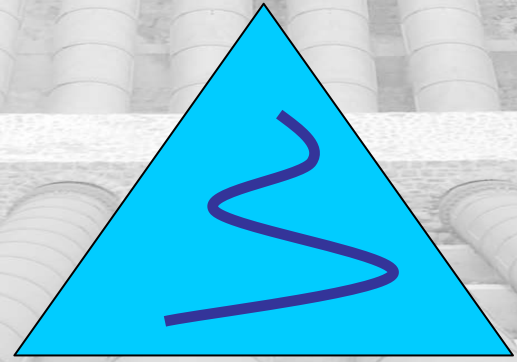
Longitudinal interruption

Hypolimnetic release

Reduced and constant discharge and sediment transport

Longitudinal interruption

Hydro, chemical and thermic peaking



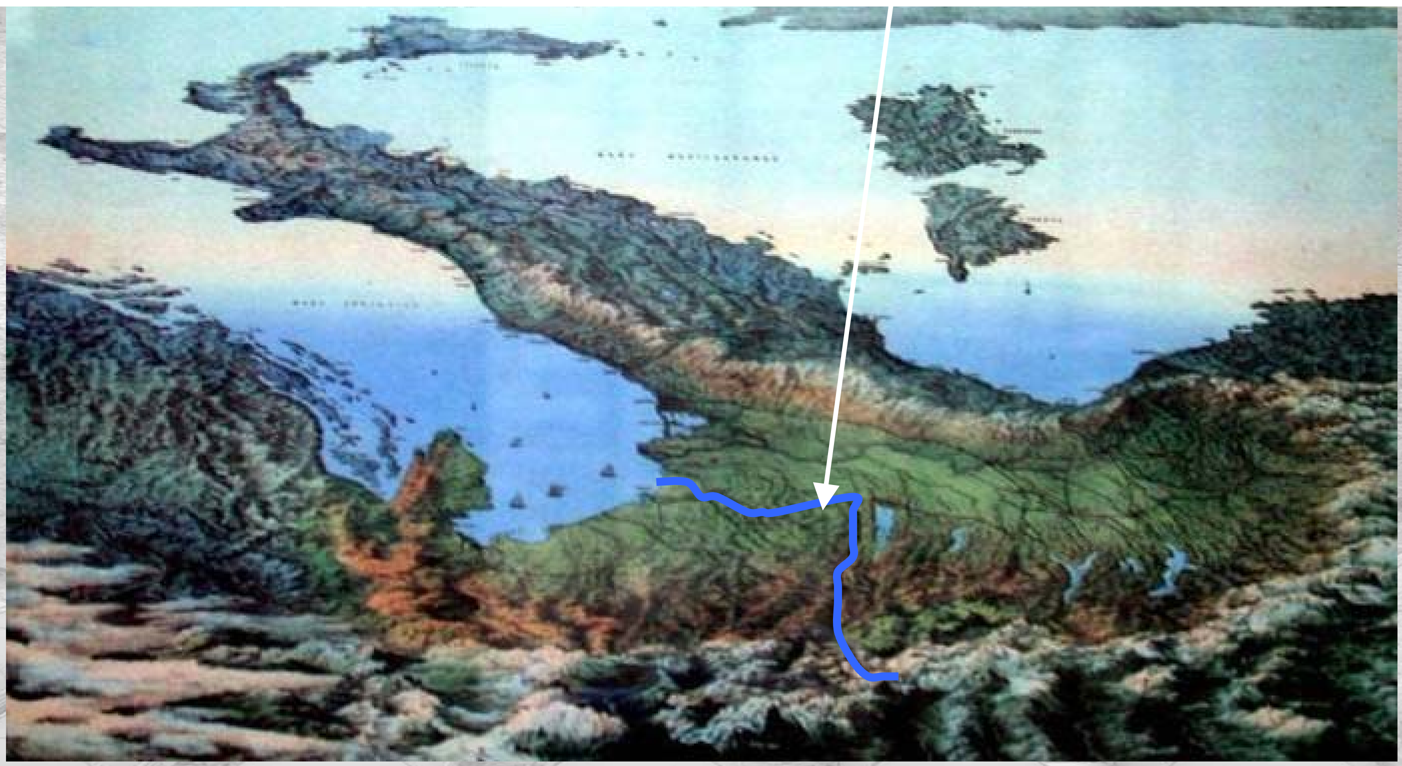
Discharge (MAGNITUDE, FREQUENCY, DURATION, TIMING, RATE OF CHANGE)

and temperature are the main driving forces influencing habitat structure and the distribution and diversity of macroinvertebrates in lotic ecosystems (e.g. Poff et al., 1997 Vannote and Sweeney, 1980; Ward, 1985; Petts, 2000).

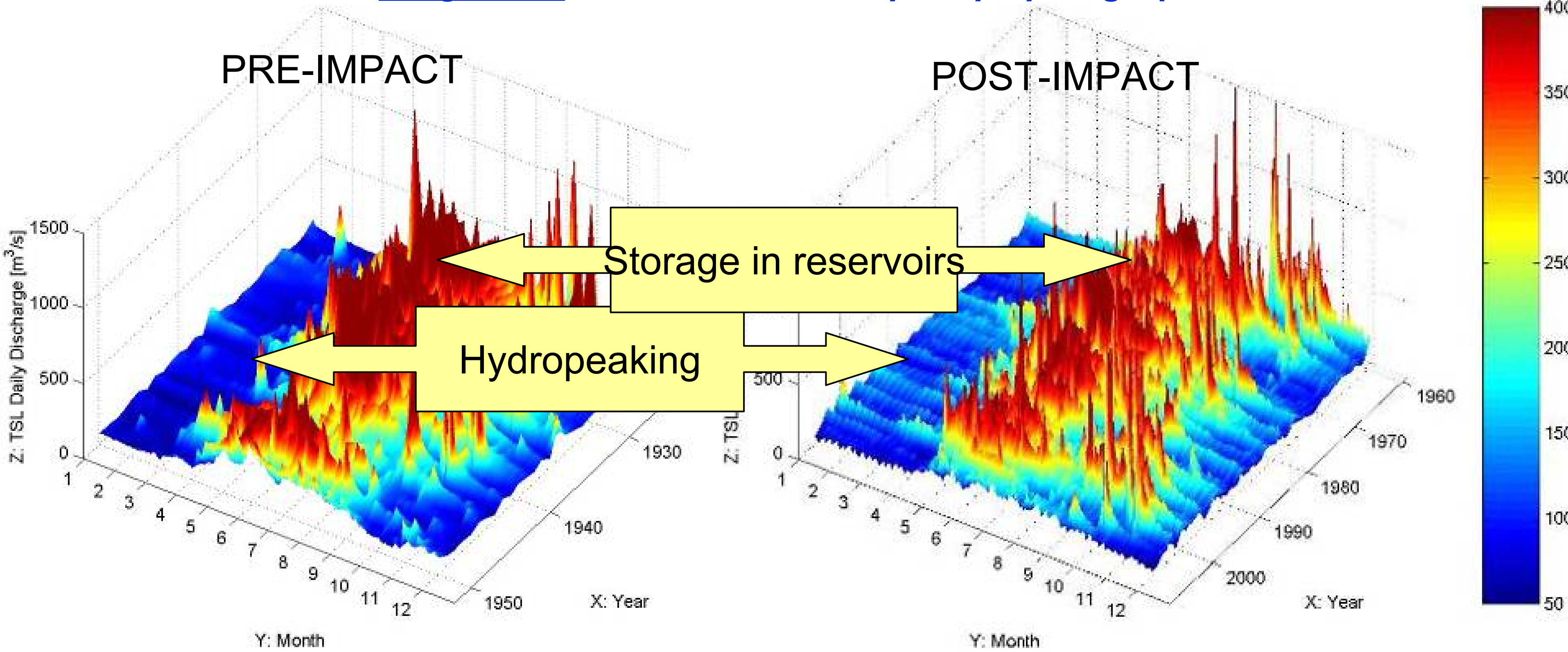
Hydropeaking and thermopeaking affect the integrity of Alpine streams

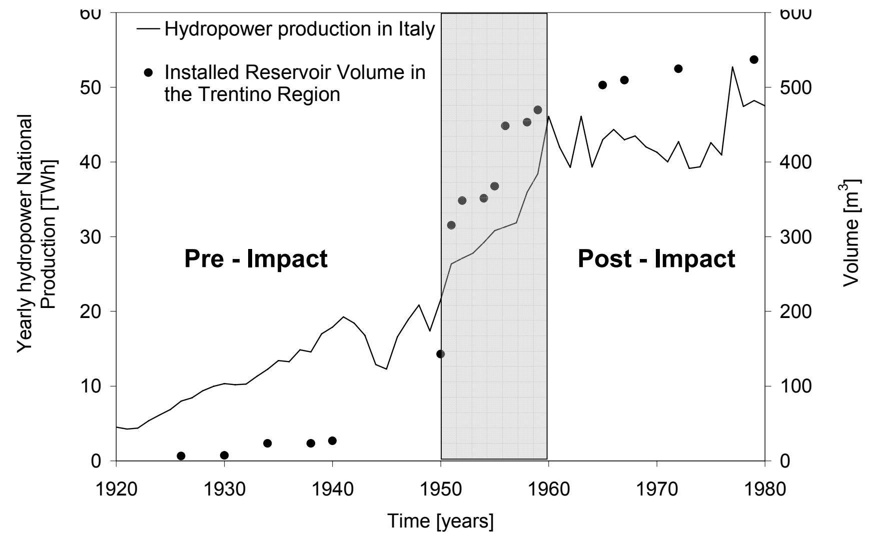
The Adige is the second longest Italian river, draining a 12,100 km² basin: the Alpine upper part of the river covers most of its drainage area as in the lowland part the river receives no tributaries.

The Adige headwaters are mainly fed by snowmelt and rain and by 185 glaciers with a total glacial surface of about 200 km²



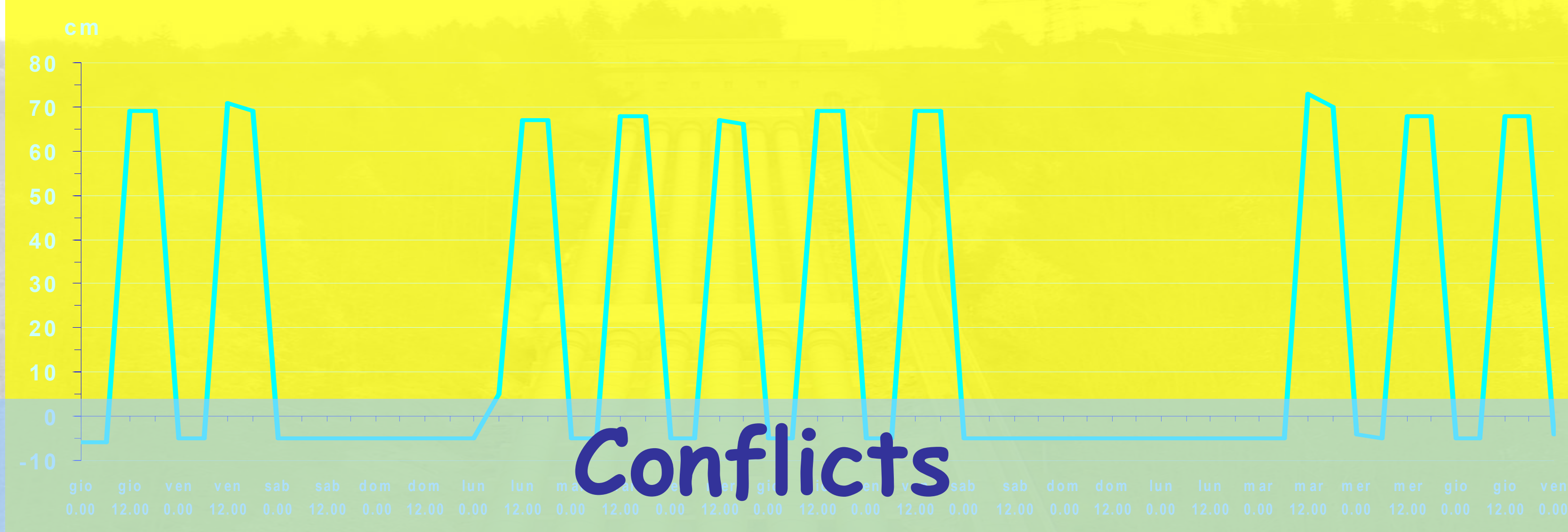
Adige river : alterations of the yearly hydrograph



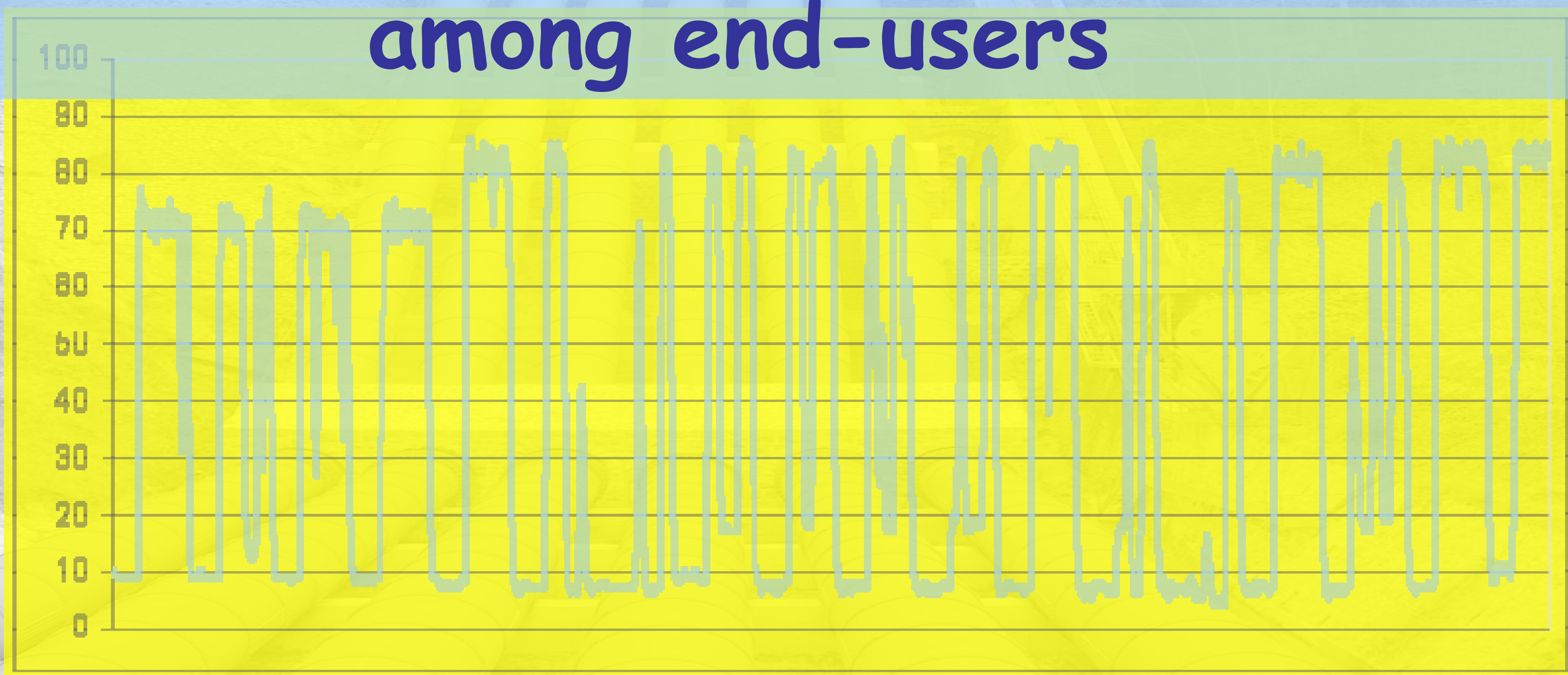


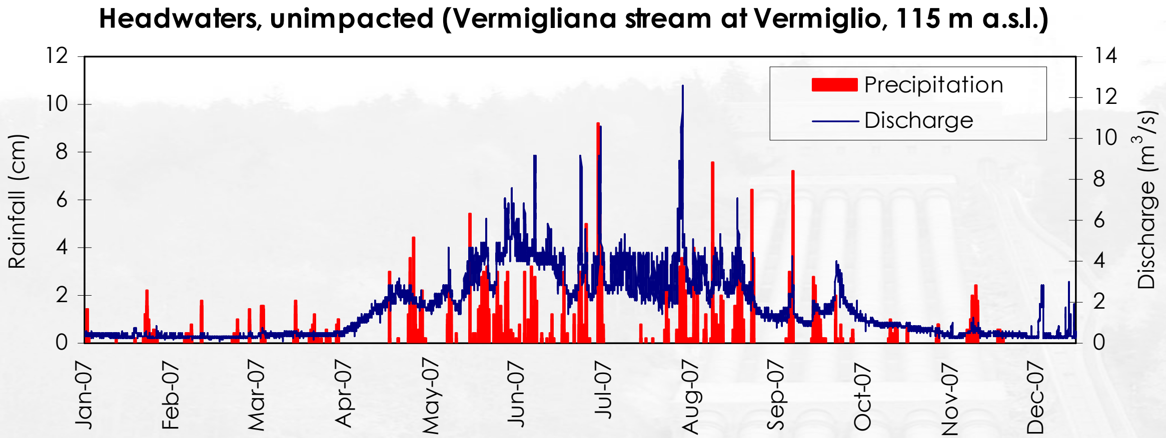
Disruption of temporal connectivity

To date, there are 30 major reservoirs in the Adige watershed with a total capacity of 571 $\times 10^6$ m^3, and they supply 34 major hydropower plants.



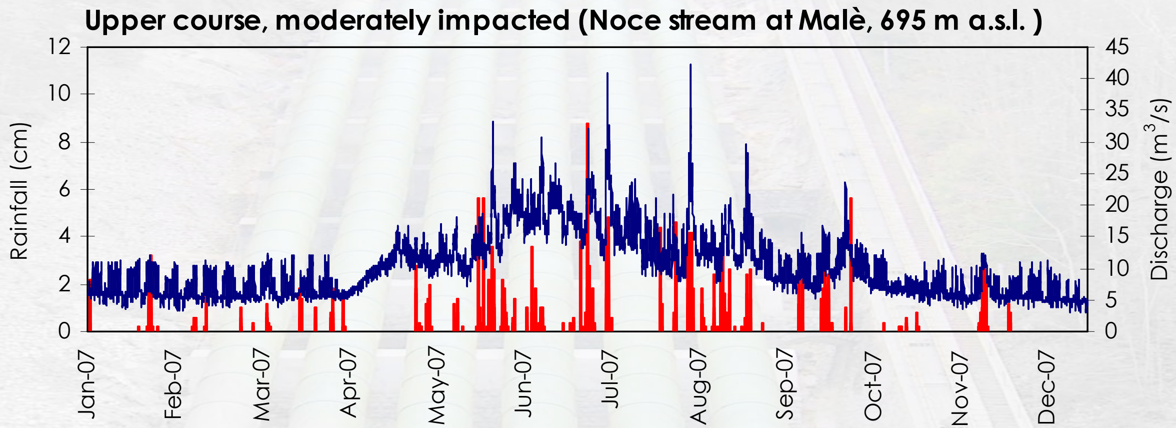
Conflicts among end-users





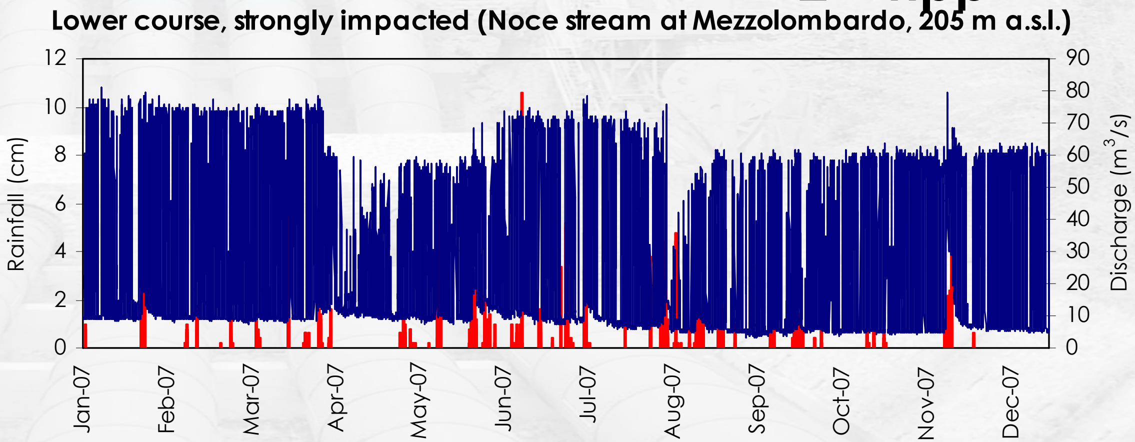
headwaters

Downstream 1st hpp

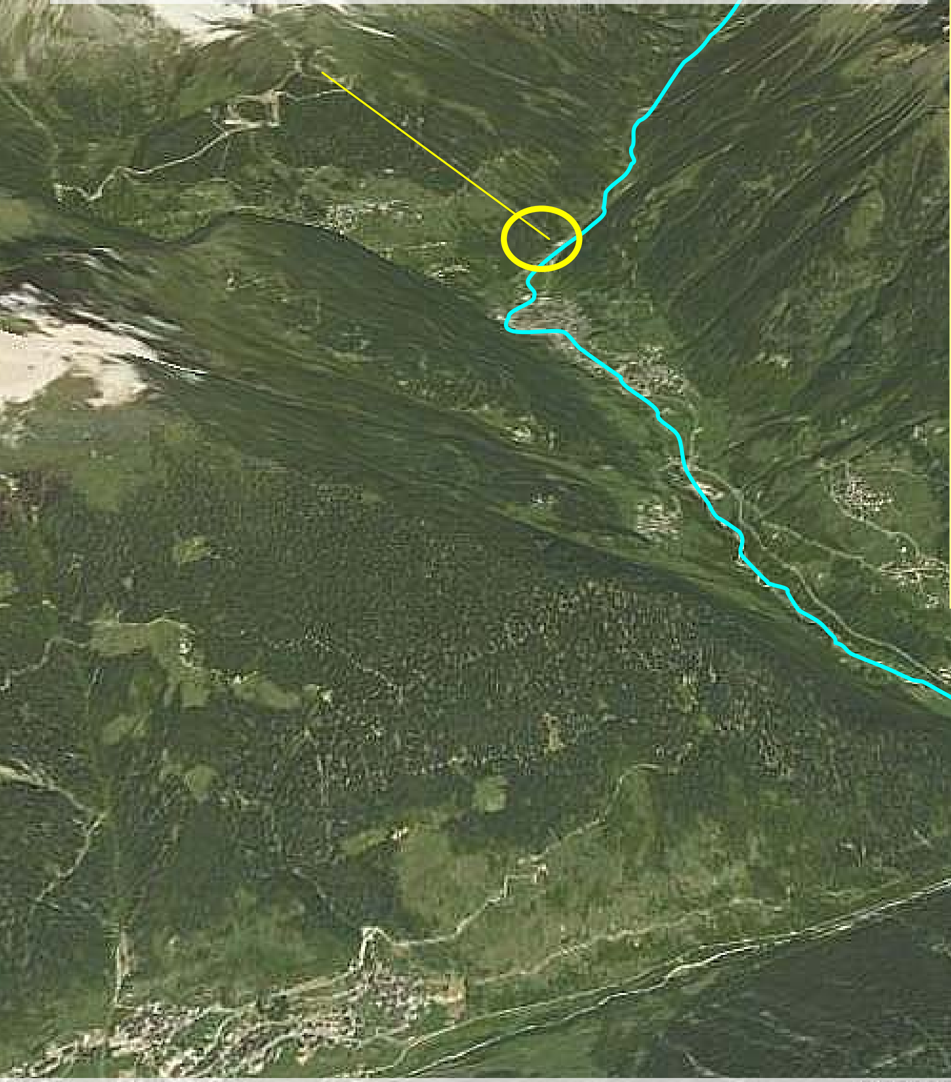


Downstream 2nd hpp

Disruption of longitudinal (and lateral, vertical) connectivity



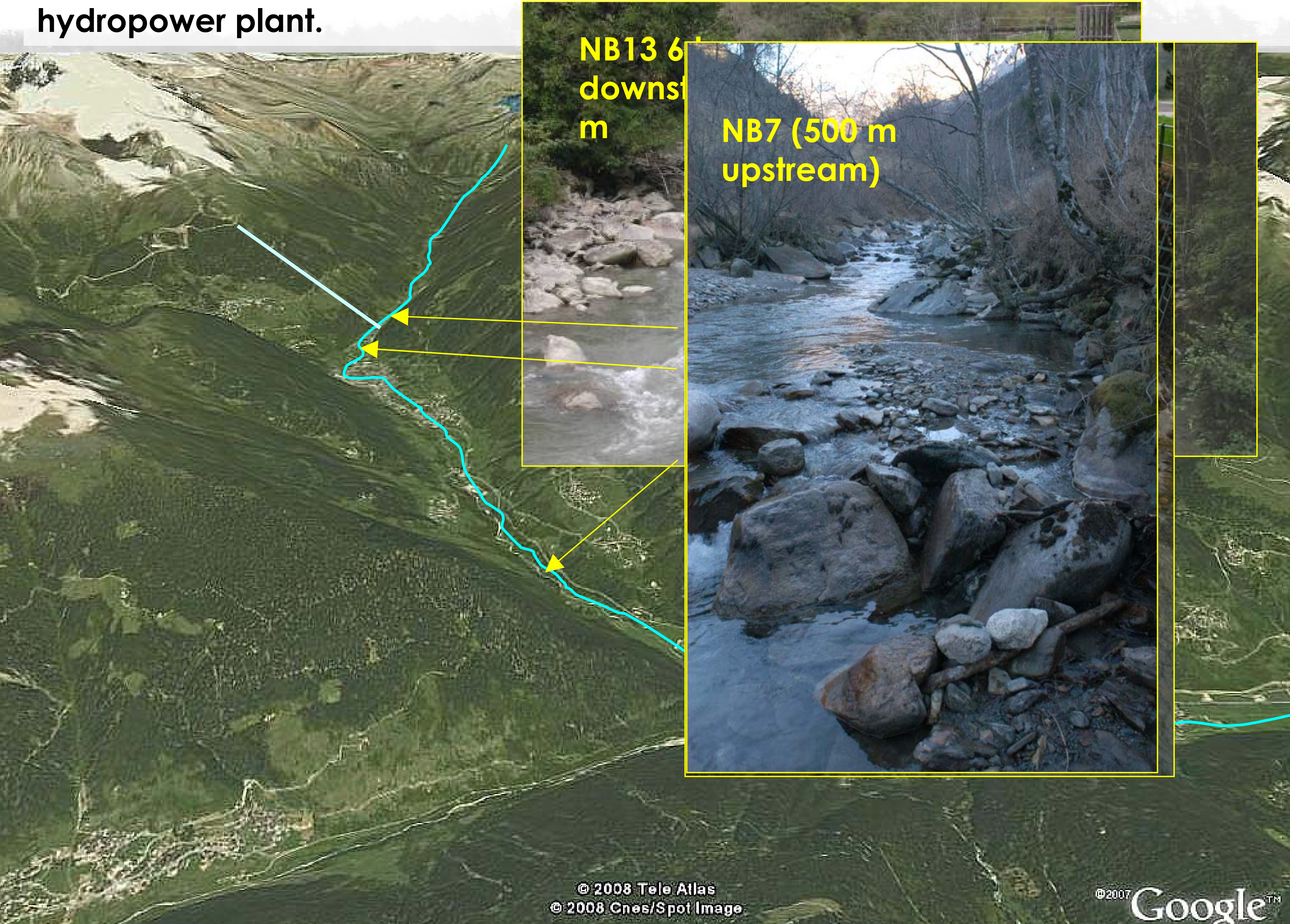
Field experiments were conducted on the Noce Bianco stream, at 1265-988 m a.s.l..

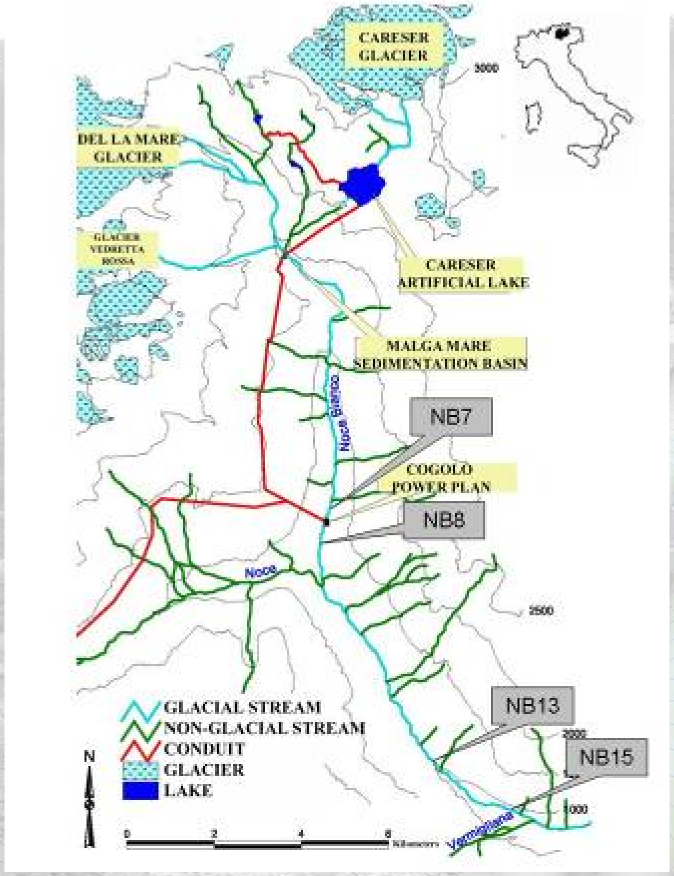


Pont (Cogolo) power plant (1208 m a.s.l.).
Max discharge 6 m^2/sec, jump 599 m, water turbinated from Careser (2600 m a.s.l.) or Pian Palù (1800 m a.s.l.) reservoirs

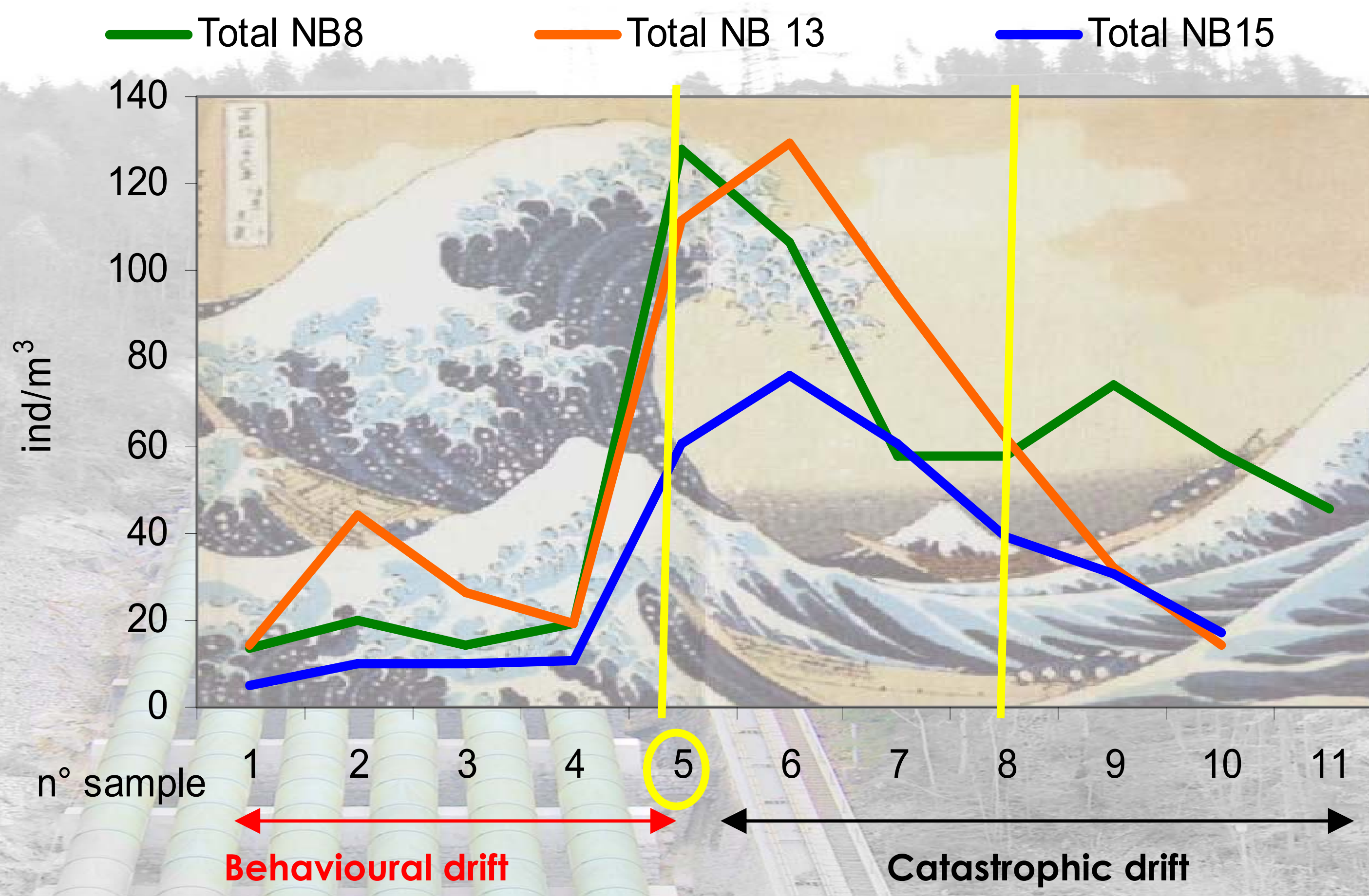
On 24-09-2006, a programmed release (no release during the night, followed by a release at maximum turbines capacity, increasing discharge of 7-fold) was arranged with the managing agency (ENEL)

Four stations were selected, one upstream and 3 downstream of Cogolo hydropower plant.





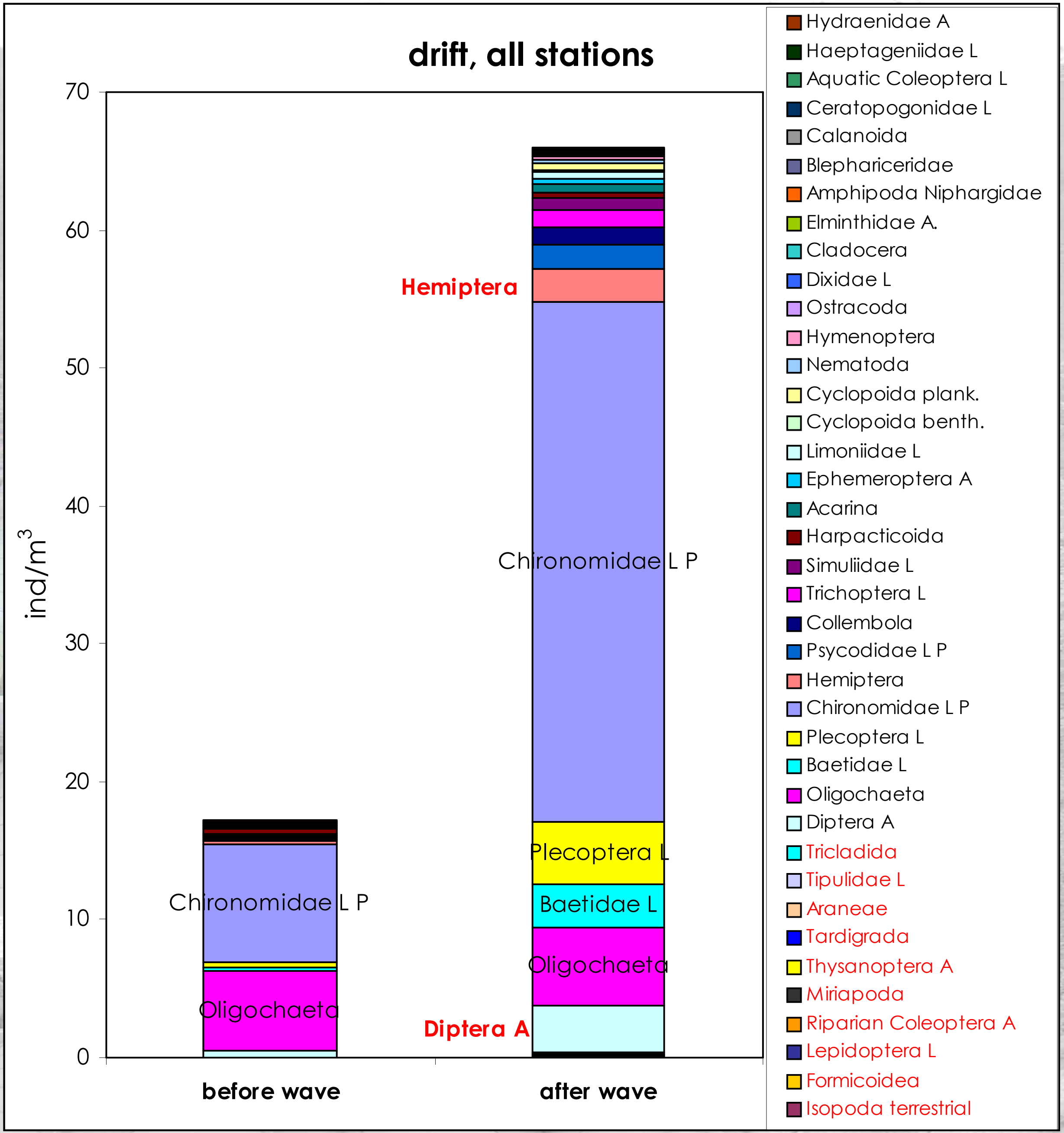
- Kick (before the release)
- Drift (4 samples of 3 replicates, every 15' before the release; 7 samples every 5' during the release at NB8, NB13, NB15)

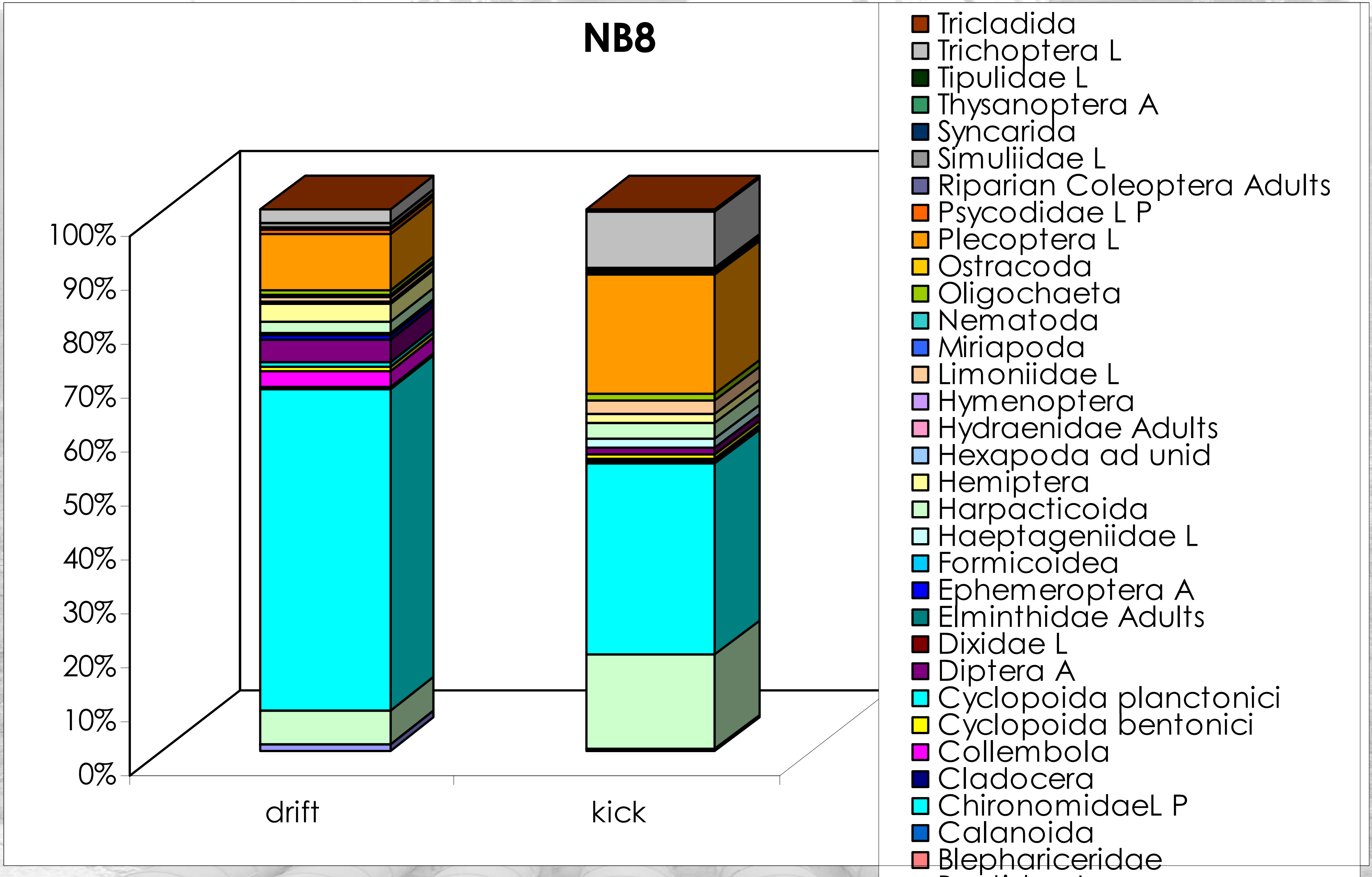


Peaks in drifting invertebrates occurred within 5’ from the beginning of the hydropeaking wave (sample n. 5);

most of the invertebrates were washed out within the first 15’ of the flow release (sample n. 8).

The composition of drift consisted mainly of aquatic insects larvae, but the rapid rise in water level also affected the terrestrial riparian communities by flushing larval and adult riparian insects

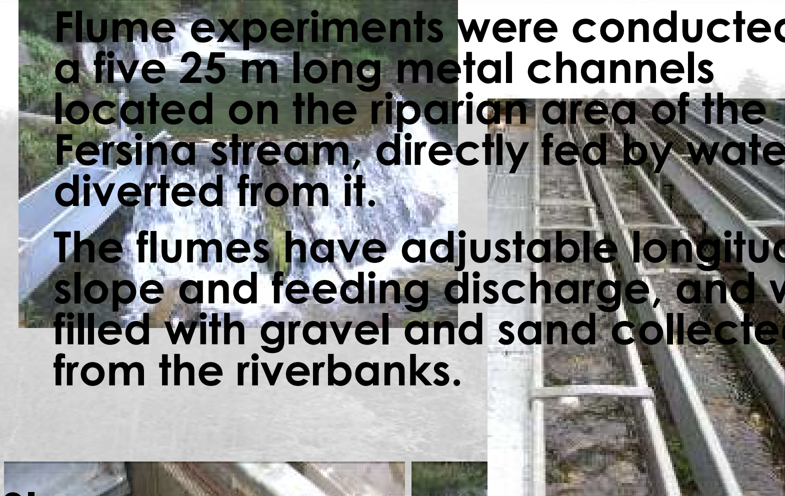


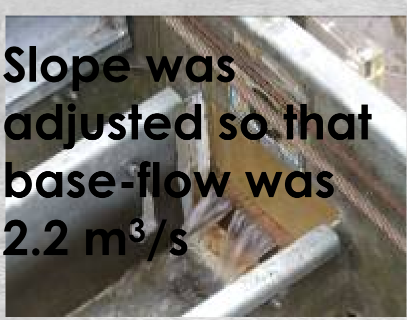


All benthic taxa were affected and collected in the drift

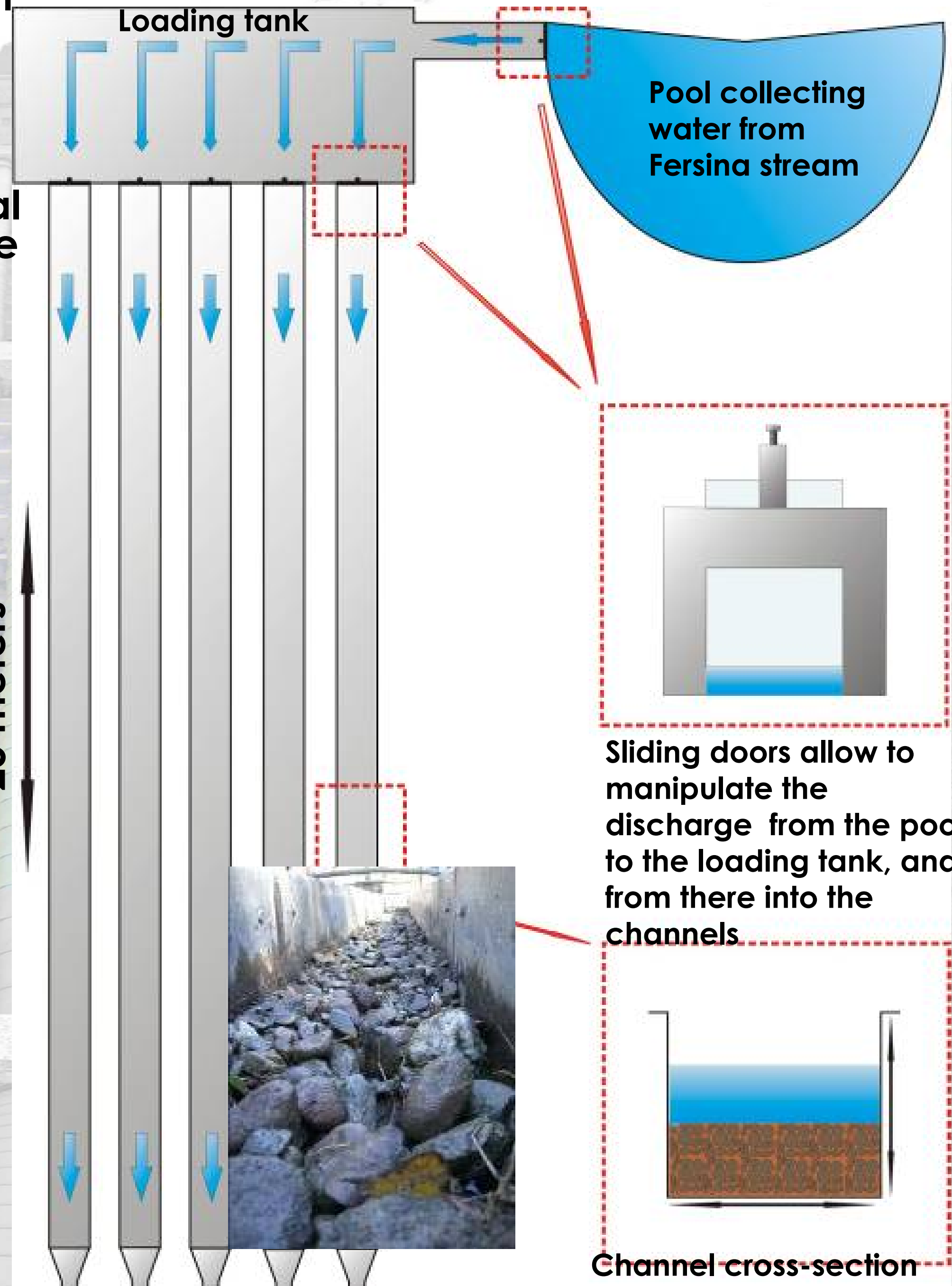
Flume experiments were conducted on a five 25 m long metal channels located on the riparian area of the Fersina stream, directly fed by water diverted from it.

The flumes have adjustable longitudinal slope and feeding discharge, and were filled with gravel and sand collected from the riverbanks.





Slope was adjusted so that base-flow was 2.2 m^3/s



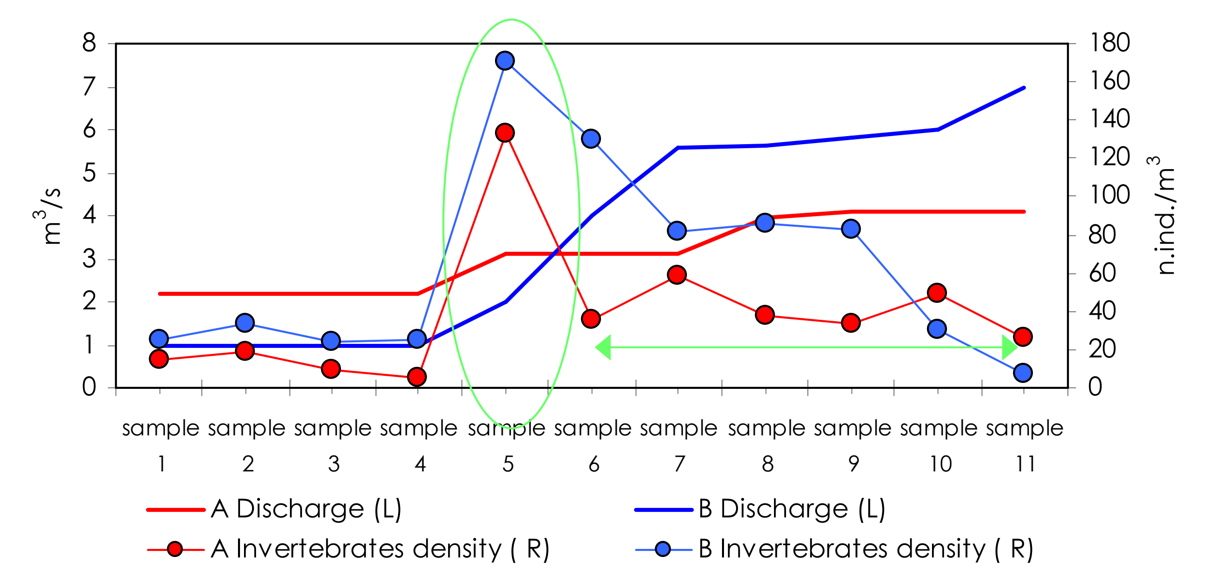
Flumes were filled with substrate and flooded on 2 October 2007

First experimental release: 30 October 2007

Two channels, two experimental changes in non-scouring flow, stepwise and abrupt

Channel A (stepwise):
- base-flow 2.2 m^3/s
- peak flow 4.1 m^3/s
- drifting invertebrates increased 9-fold;

Channel B (abrupt):
- base-flow 1 m^3/s
- peak flow 7 m^3/s
- drifting invertebrates increased 7-fold



Peaks in drifting invertebrates occurred within 5 min from the beginning of the hydropeaking wave (sample no 5);

Invertebrates **continued to drift** for more than 25 min in the abrupt change, and for 20 min in the stepwise increase

The flume and experiments confirmed the results of the field experiments:

- several high flow events of about the same magnitude cause considerable losses of benthic populations to the drift and hinder life phases as pupation and emergence,
- the effect of abrupt changes can be more severe than stepwise (last longer), however stepwise changes remove more invertebrates.

- More flume experiments are required to separate the effects of thermopeaking from those of hydropeaking

CONCLUDING REMARKS

In Alpine regions, intermittent hydropower generation has high economical relevance, being the most important renewable electricity source, with no CO_2 emission.

<u>However</u>:

- hydropower generation creates serious ecological alterations;
- like most large Alpine rivers, the Adige has been greatly altered in historical times;
- the ecosystem benefits and services expected from river restoration projects may be severely reduced by the overwhelming effects of altered flow and temperature regimes due to hydropeaking and other phases of hydropower production.

<u>Therefore</u>

- Research and restoration projects should aim to maintain and possibly increase hydropower production while meeting ecological demands;
- this approach will also help fulfilling the requirements of the WFD 2000/60 EC, as regards Heavily Modified Water Bodies.

The (possible) way ahead

Select headwater stream typologies to be abstracted in order to maintain the unique Alpine freshwater biodiversity

Emendations appear expensive and probably not cost-effective in Alpine environments

Hydropeaking is a major problem and case specific emendations are possible, mainaining production. A basin approach is mandatory

We would like to thank:

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and all of you for your kind attention