

RESPONSE OF FISH ASSEMBLAGES TO FLOW VARIATIONS IN HYDROPEAKING STREAM REACHES

Clarisse JUDES^{1,2}, Hervé CAPRA², Agnès BARILLIER³, Nicolas
LAMOUROUX², Véronique GOURAUD¹

1: EDF R&D LNHE – National Hydraulics and Environnement Laboratory , Chatou, France

2: Irstea Lyon – Dynam, Villeurbanne, France

3: EDF CIH, Chambéry, France



HYNES partnership

Context



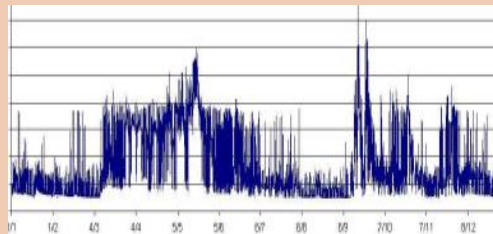
Low electricity demand ⚡

Base flow

High electricity demand ⚡

Base flow +
turbinated flow

Flow



Time



High flow variation

High variation of hydraulic parameters

Current velocity/water depth/wetted surface

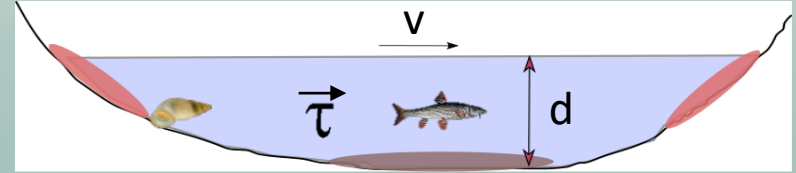
Context

In stationary hydraulic conditions

Hydraulic conditions:
 v = current velocity
 d = water depth



Organism
 habitat
 selection



Regulated reach

Base flow



High temporal and spatial variability of habitat attractiveness

Hydropeaking flow



Near bank

Unsuitable

Stranding
 risk
 (Halleraker, 2003;
 Salveit, 2001)

Suitable

Middle river bed

Suitable

Unsuitable

Drift risk
 (Bruno et al, 2013)

How do fish and macroinvertebrates respond to high hydraulic variations induced by hydropeaking?

PhD
Axis 1

Fish assemblages

- Qualitative description

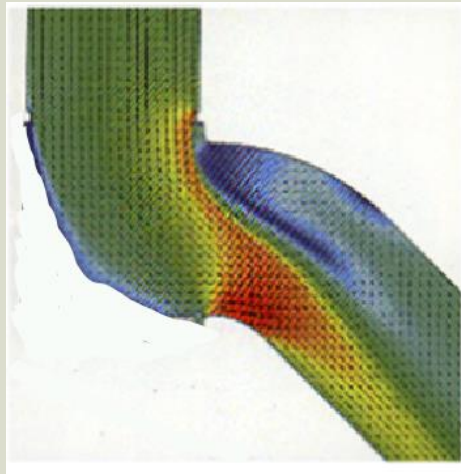
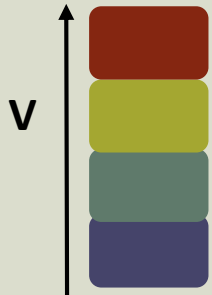
Bain *et al.* 1988; Freeman *et al.* 2001; Schmutz *et al.* 2015

Objective: **Identify descriptors of hydrologic variation that induce changes in fish assemblages**

Facing the results of the two axes

PhD
Axis 2

Habitat selection by fish and macroinvertebrate



- Steady habitat preferences
- Habitat history can influence fish behaviour

Patton & Braithwaite 2015; Capra *et al.* 2017

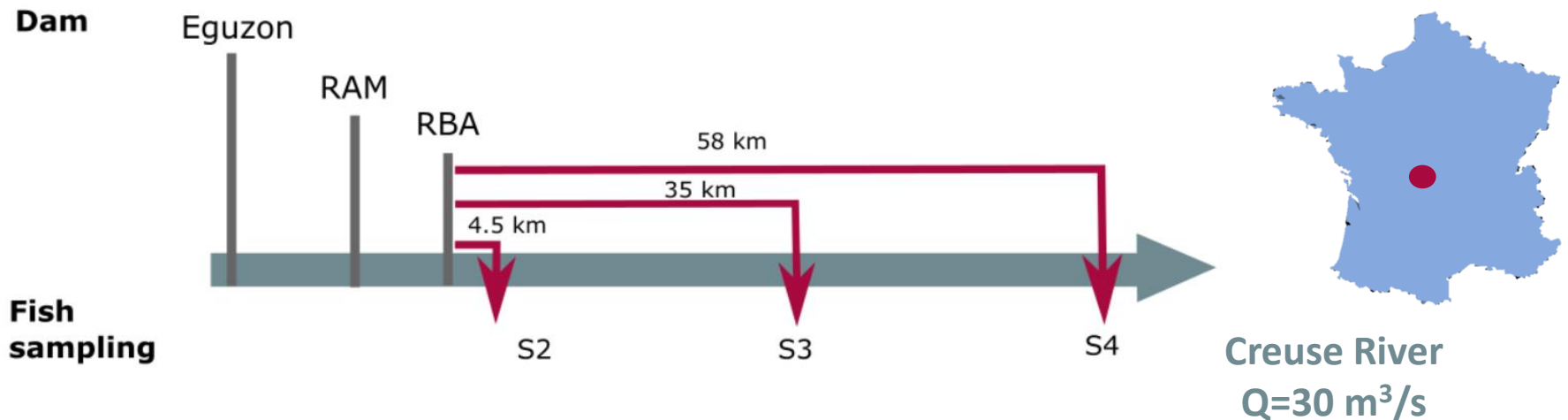
Objective: **Dynamics hydraulic habitat preference**

Axis 1 : Materials and Methods

Data already available - 14 studied sites in France monitored during 6 to 10 years



Zoom on one site : Eguzon



Data available :

Fish sampled annually by electrofishing from 2006 to 2016 at the end of summer
Hourly flow data at the 3 reaches (directly from a gauging reach or modelled)

Materials and Methods

Class of flow

Median of flow
Low/high flow

Hydrological indices

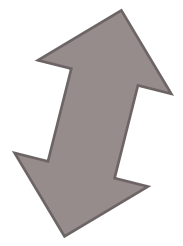
Floods events

Maximal flow during the flood
Duration of flood

Flow variation

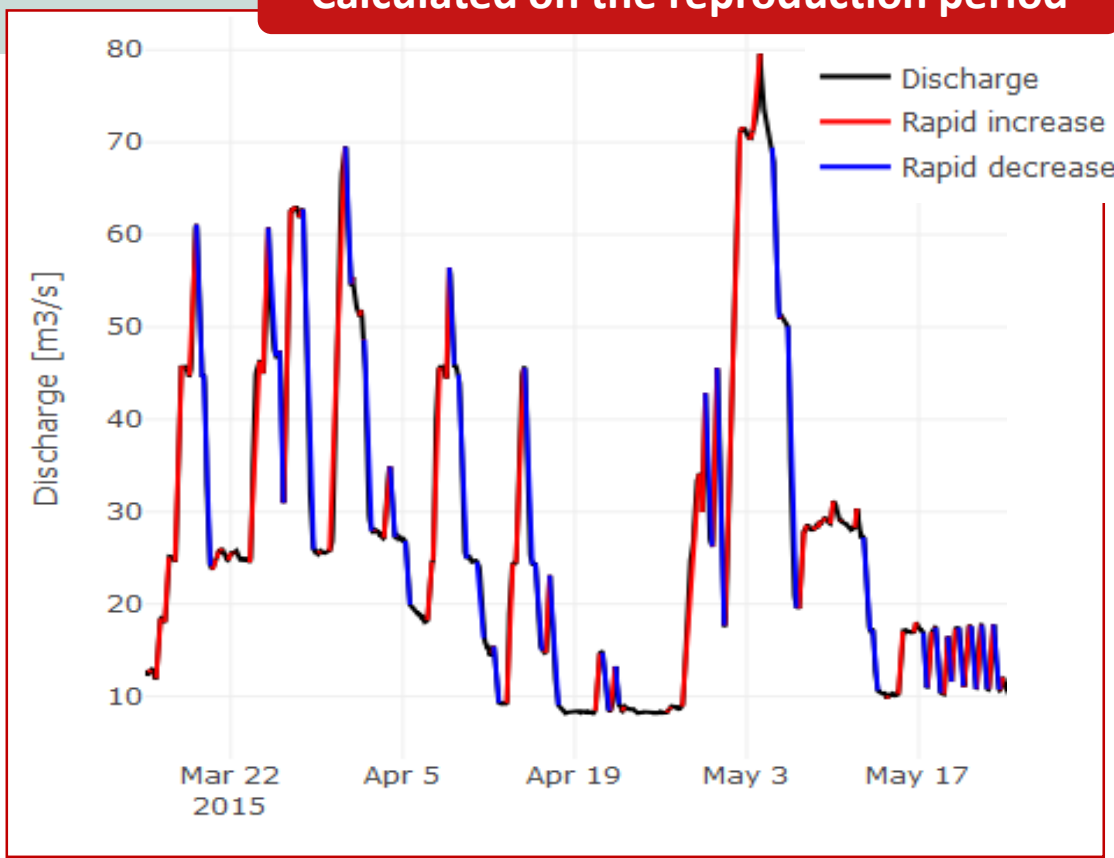
Number of increase/decrease events
Maximum ramping rate
....

Calculated on the reproduction period

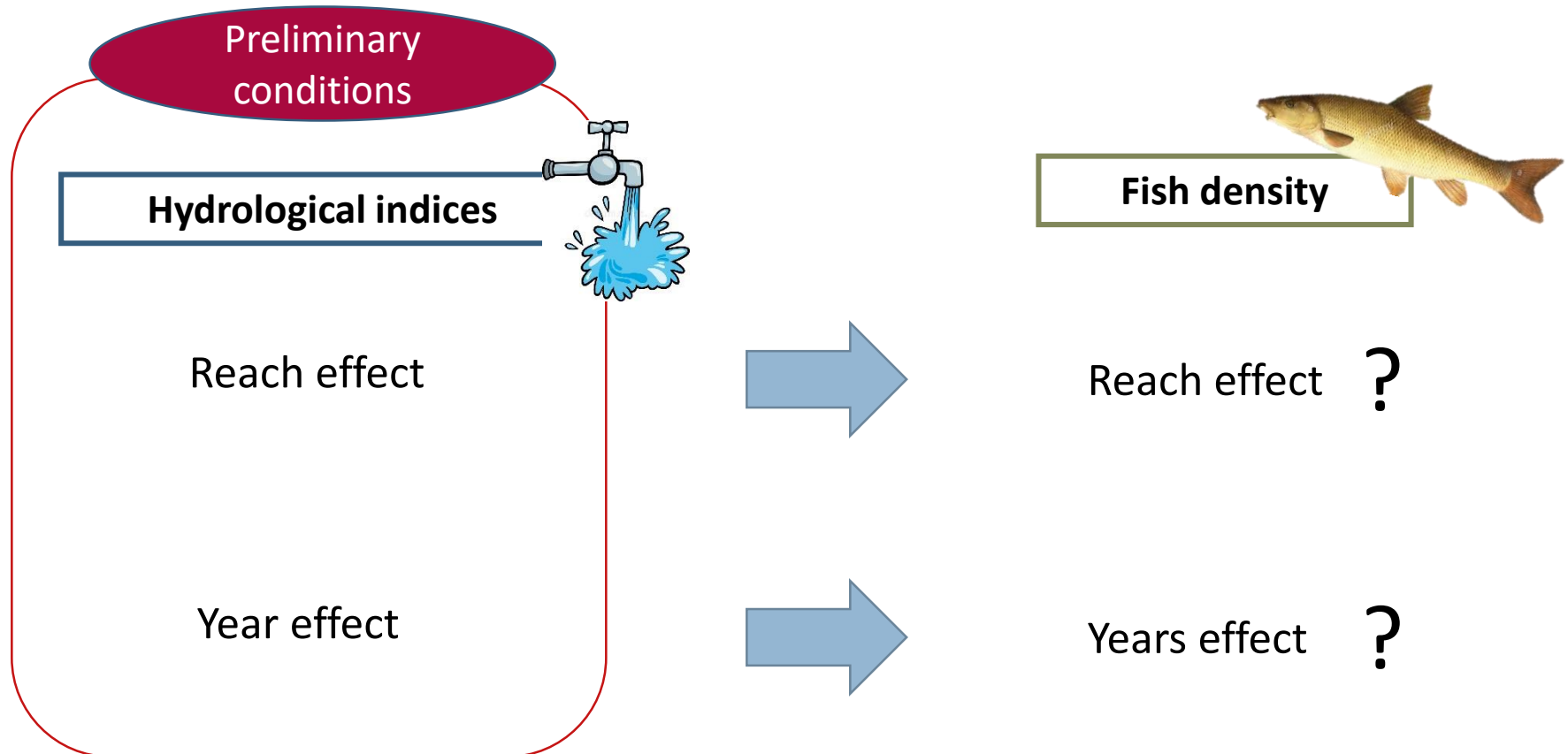


Fish density

young of the year



My first results : **Descriptive analysis by PCA inter-reach and inter-year**



Results: Fish assemblages

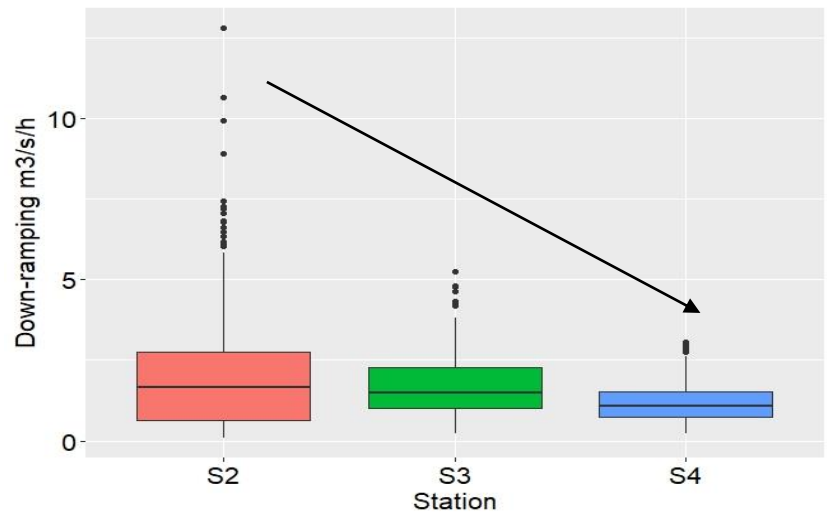
- ➔ On average 17 species and 118 individuals/100m² were caught
- ➔ We choose to kept only **young of the year (YoY)** individuals of 6 species :
 - 4 lithophylic species: *A. bipunctatus*, *B. barbuis*, *P. phoxinus*, *S. cephalus*
 - 2 phyto-lithophylic species: *A. alburnus* , *G. gobio*



Results: Effect inter-reach



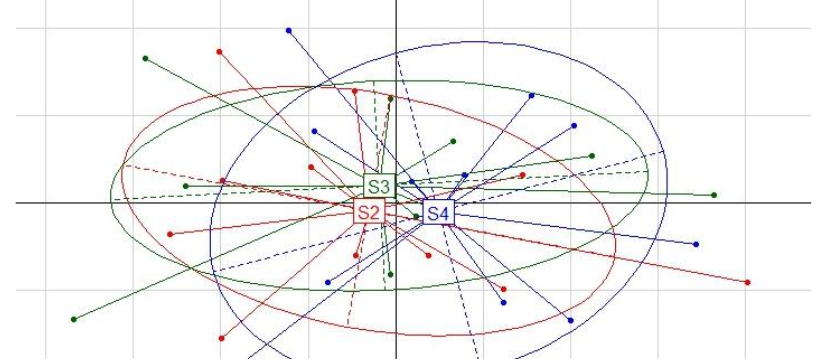
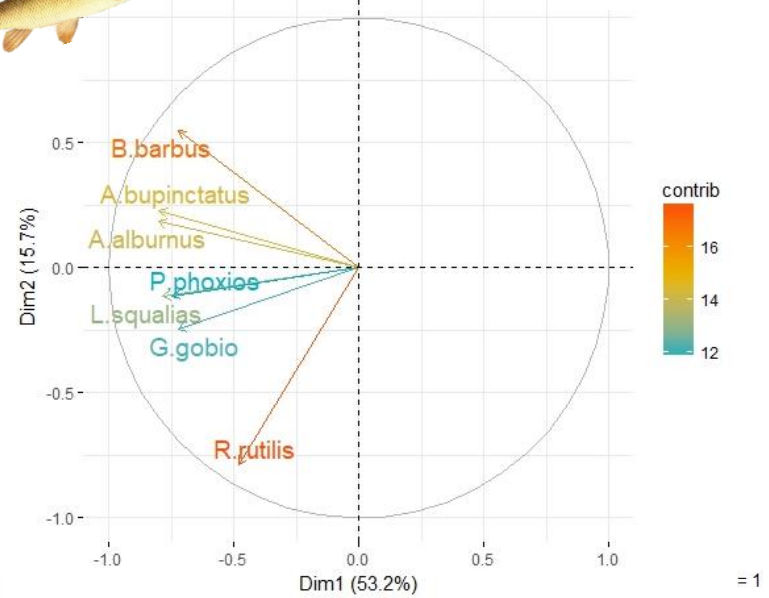
Reach effect



Down ramping by event decreases with dam distance



Reach effect



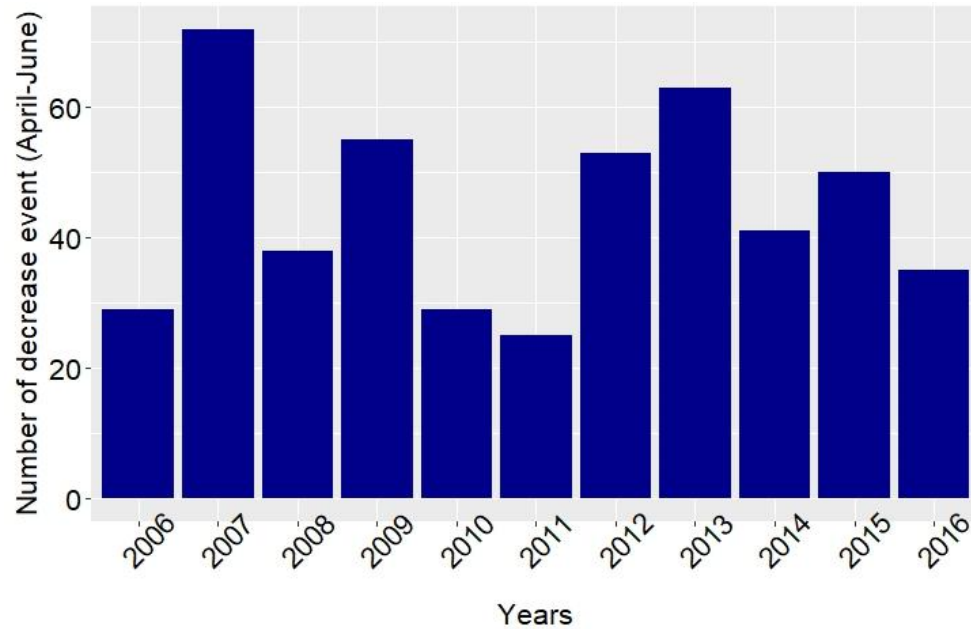
Projection of the fish taxa/reach into the within-sites PCA F1xF2 factorial axes

The range of perturbation studied does not allow us to conclude on how the perturbation intensity affects fish assemblages

Results: Year effect



Year effect



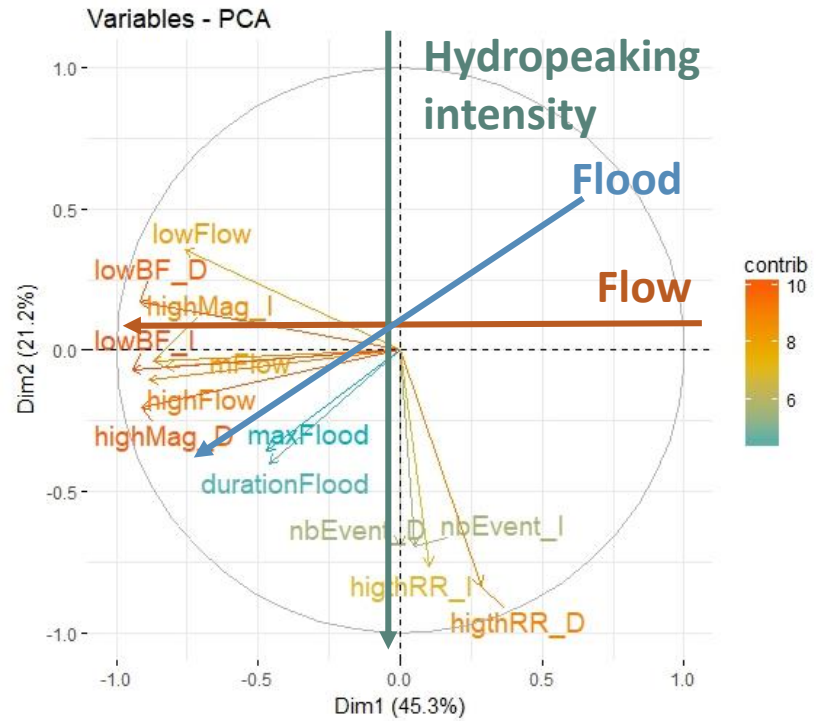
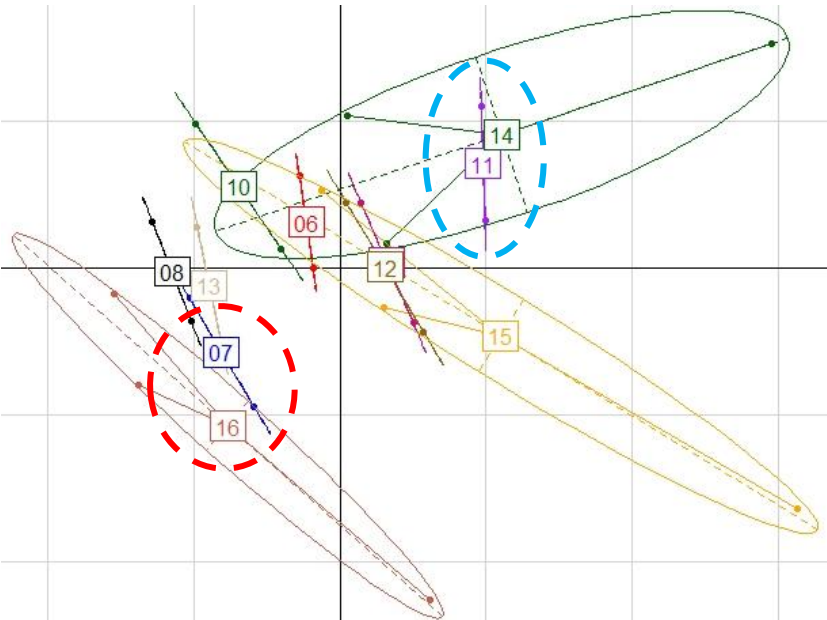
Time series of one hydrological perturbation index

Hydrological perturbation seems to be year-dependent

Results: Year effect



Year effect



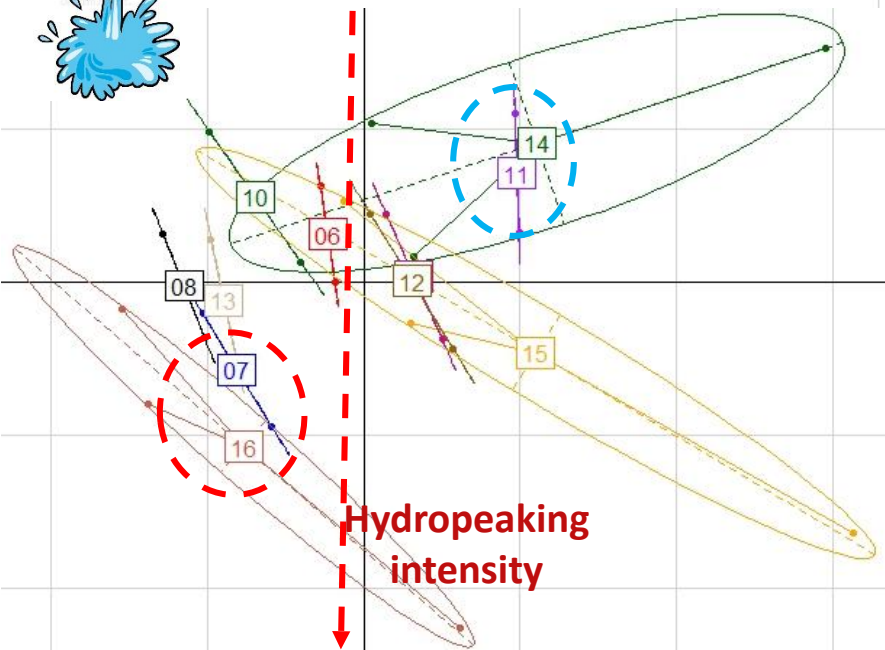
Projection of the years/hydrological indices into the within-sites PCA F1xF2 factorial axes

Hydrological perturbation seems to be year-dependent

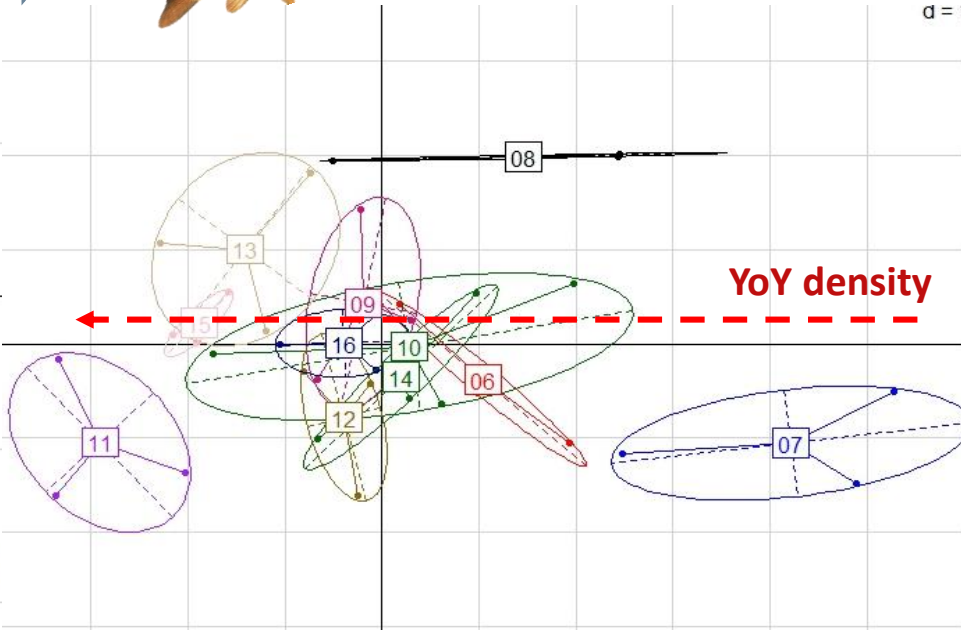
Results : Years effect



Year effect



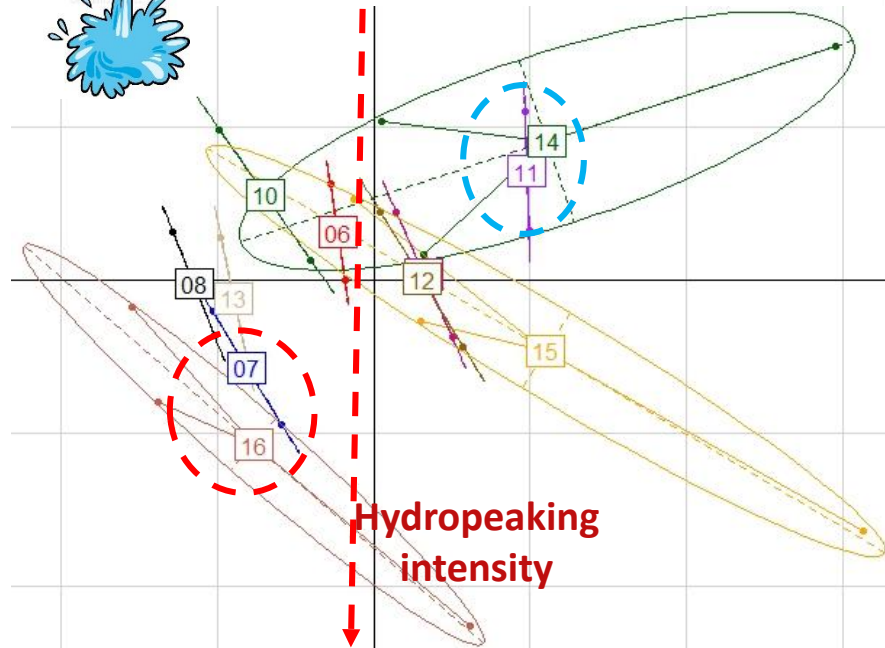
Year effect



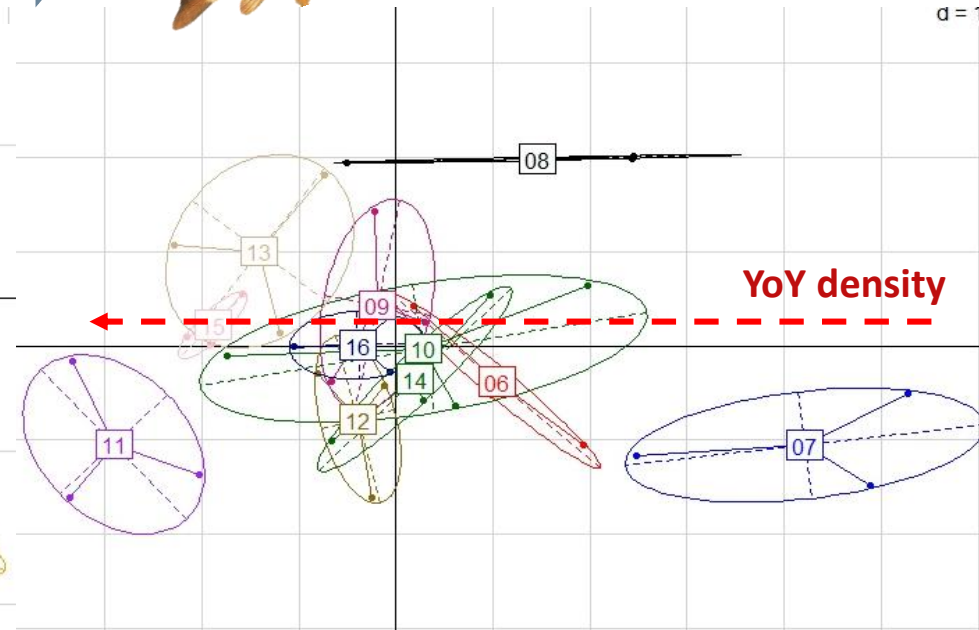
Results : Years effect



Year effect



Year effect



Confounding factors make the understanding of hydropeaking influence difficult

My aim for the future is to:

- ➔ Disentangle the effect of natural variables (flood, temperature) from the effect of hydropeaking variation
- ➔ Take into account hydraulic variation

PhD Axis 2: Method

Fish and macroinvertebrate taxa abundances

Hydraulic conditions during sampling

Historic hydraulic variation

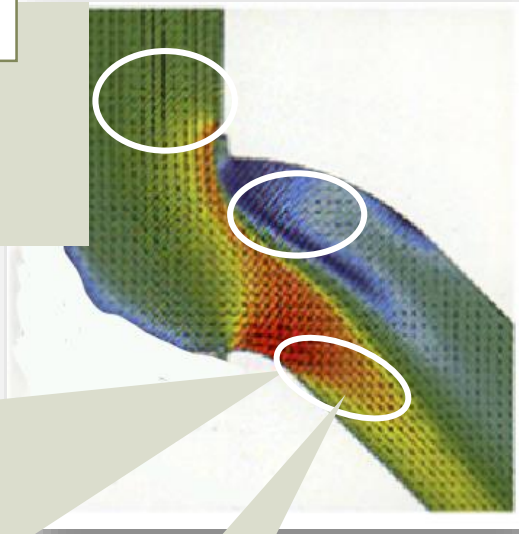


+

1

2D hydraulic model

Identify areas of interest (with different hydraulic histories)



2

Fish and macroinvertebrates sampling



Electrofishing
(600 points/reach)



Benthos/hyporheos sampling
(30 benthos-30 hyporheos/reach)

3

Habitat characteristics during sampling

4

2D hydraulic model

Hydraulic history

Rate of dewatering
Time period with current velocity higher than 0.7 cm/s

Conclusions and perspectives

Conclusion on first results axis 1 :

- Confounding factors make the understanding of hydropeaking influence difficult
- We need to :
- Disentangle the effect of natural variables (flood, temperature) from the effect of hydropeaking
 - Study hydraulic parameters

Perspective : Generalization from our studied station to all regulated reaches in France

Data partially available



Operational objective

Identify parameters or thresholds that induce changes in fish and macroinvertebrate assemblages and/or behaviour



Thank you for your attention

Bain N, Finn JT. (1988) “Streamflow regulation and fish community structure.” Ecological Society of America. 2:383:392.

Salveit SJ, Halleraker JH, Arnekleiv JV, Harby A. (2001) “Field experiments on stranding in juvenile Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) during rapid flow decreases caused by hydropeaking.” Regulated Rivers: Research & Management 17: 609–622.

Freeman MC, Bowen ZH, Bovee, KD, Irwin, ER. (2001). Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. Ecol. Appl. 11: 179–190.

Halleraker JH, Salveit SJ, Harby A, Arnekleiv JV, Fjeldstad HP, Kohler B. (2003) “Factors influencing stranding of wild juvenile brown trout (*Salmo trutta*) during rapid and frequent flow decreases in an artificial stream.” River Res Appl 19:589–603.

Bruno MC, Siviglia A, Carolli M, and Maiolini B. (2013) “Multiple drift responses of benthic invertebrates to interacting hydropeaking and thermopeaking waves.” Ecohydrology. 6:511–522.

Patton BW, Braithwaite VA. (2015) “Changing tides: ecological and historical perspectives on fish cognition”. WIREs Cognitive. Science. 6:159–176.

Schmutz S, Bakken TH, Friedrich T, Greimel F, Harby A, Jungwirth M, ... Zeiringer G. (2015) “Response of fish communities to hydrological and morphological alterations in hydropeaking rivers of Austria.” River Research and Application. 31: 919–930.

Capra H, Plichard L, Bergé J, Pella H, Ovidio M, Mcneil E, Lamouroux N. (2017) “Fish Habitat Selection in a Large Hydropeaking River: Strong Individual and Temporal Variations Revealed by Telemetry.” Science of the Total Environment. 578: 109-120.