

# Effects of spatio-temporal variability of hydropeaking on juvenile fish

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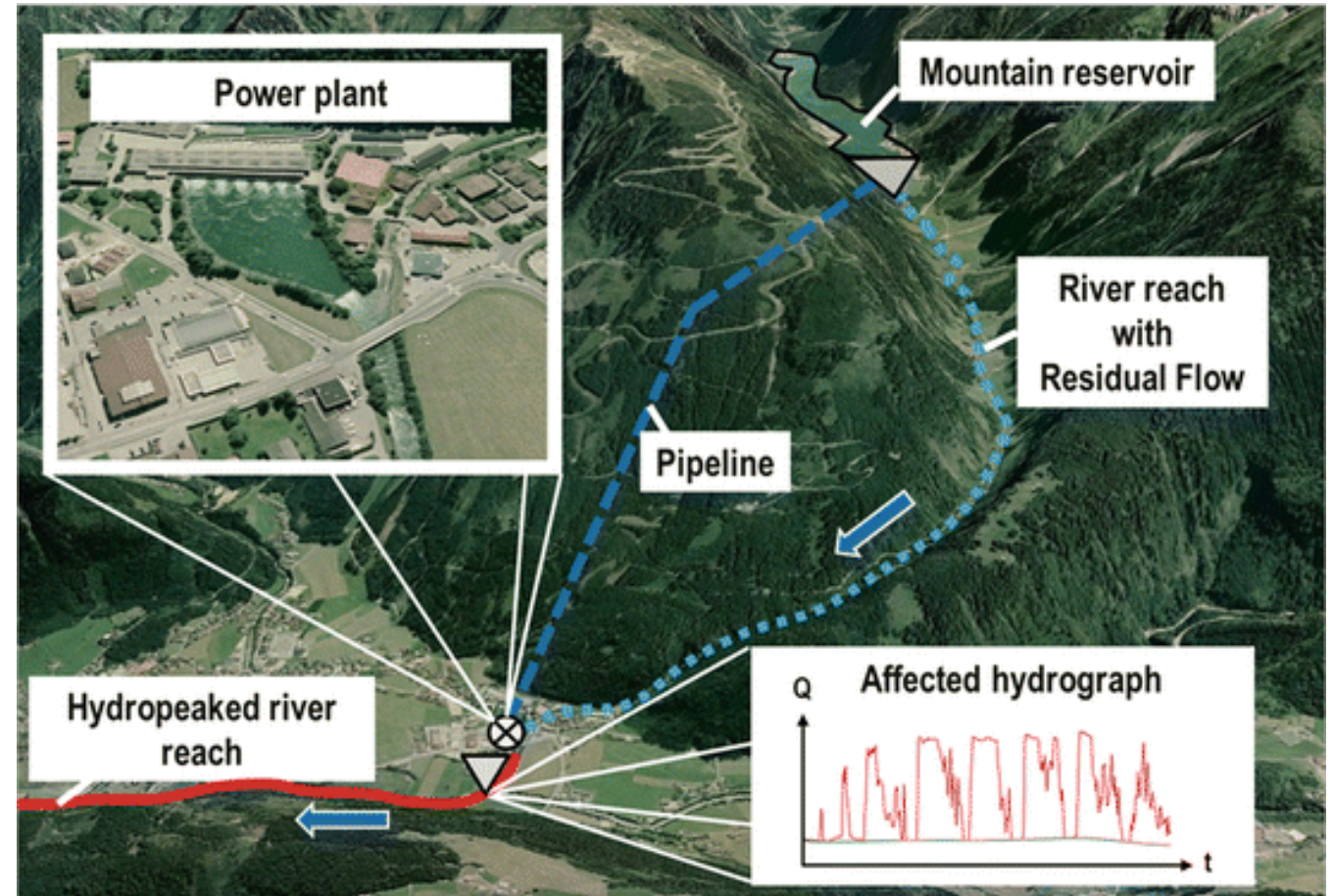
# Background

## Hydropeaking

Artificial flow fluctuations

Flow characteristics shape **physical habitats** and influence **organisms**<sup>1</sup>

**Fish** are one of the affected organism groups<sup>2</sup>



Schematic of a storage power plant<sup>3</sup>

<sup>1</sup>Bunn & Arthington, 2002; Poff et al., 1997; <sup>2</sup>Schmutz et al., 2015;

<sup>3</sup>Greimel et al., 2018

# Background

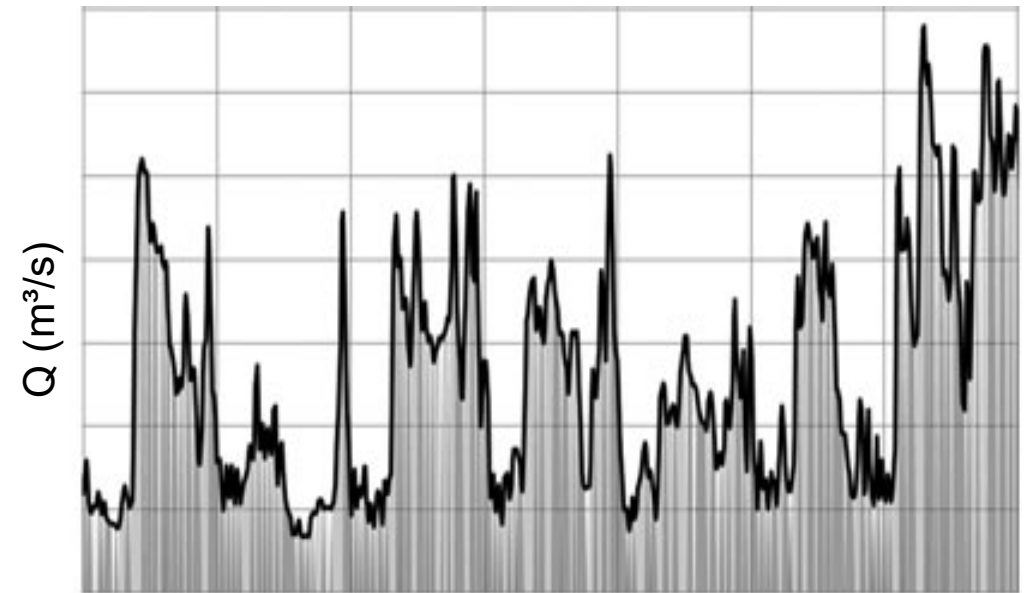
## Impact on fish

### Effects on fish<sup>1</sup>

- *Drift*
- *Stranding*
- *Dewatering of spawning grounds*

### Early life stages are sensitive to hydropeaking<sup>2</sup>

- *Preference for nearshore habitat*
- *Developing swimming ability*



Time  
Hydrograph with strong hydropeaking<sup>3</sup>

<sup>1</sup>Auer et al., 2014, 2017; Saltveit et al., 2001; Casas-Mulet et al., 2014

<sup>2</sup>Young 2011, Schmutz 2015, Heggenes & Traaen, 1988, Moreira et al., 2019

# Background

## Austrian situation

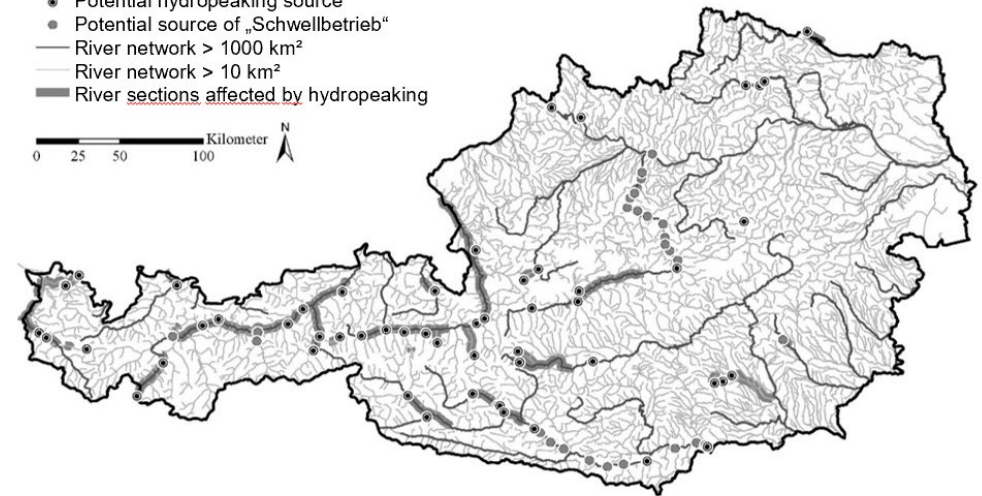
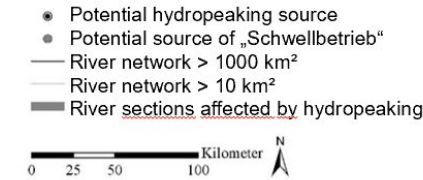
## Hydropeaking in Austria

## Evaluated rivers

- with Hydropeaking impact
- without Hydropeaking impact

## Main fish species

- *Salmo trutta* - Brown trout
- *Thymallus thymallus*  
European grayling
- Also cyprinids



BMLRT (2017): Nationaler Gewässerbewirtschaftungsplan 2015.

Greimel, F., Zeiringer, B., Höller, N., Grün, B. & S. Schmutz (2017): Anhang zu technischer Bericht A - Kurzfristige Abflussschwankungen in Österreich. Ergänzung zu Endbericht: Suremma



# Background

## Austrian situation



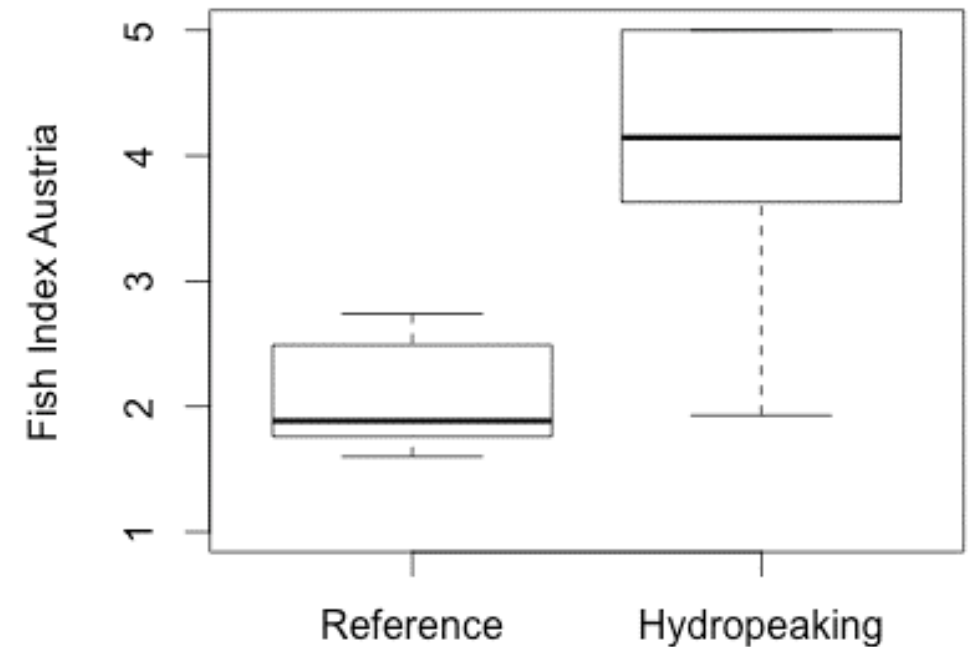
Austrian method: Fish Index Austria<sup>1</sup>

Hydropeaking evaluation based on  
Community level<sup>2</sup>



Method with focuses on

- **Timely** monitoring of mitigation measures
- Early life stages (highly vulnerable)
- In the sensitive time periods (spring and summer)



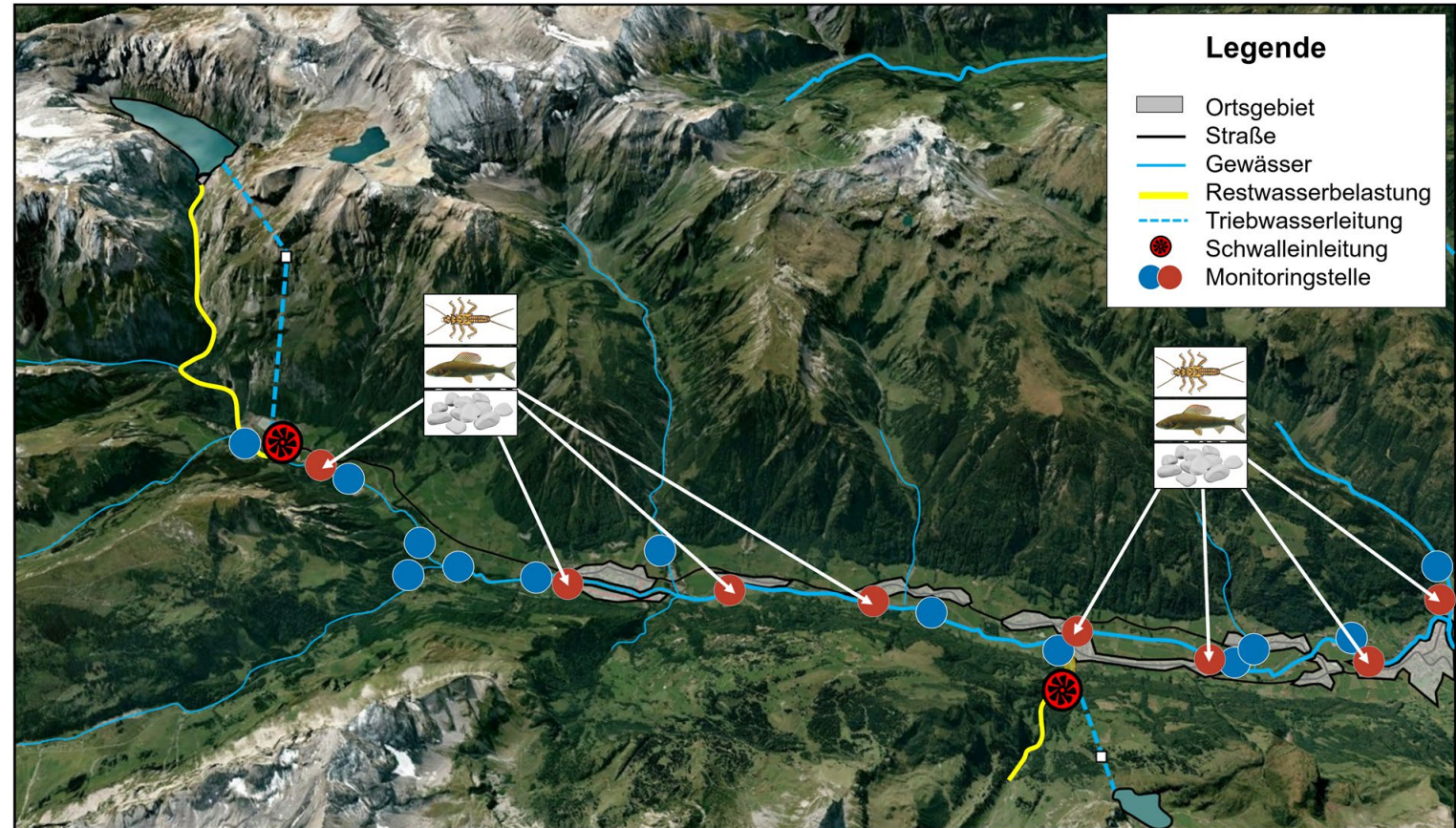
Fish Index Austria for Reference and Hydropeaking sites<sup>2</sup>

<sup>1</sup>Haunschmid et al., 2010; <sup>2</sup>Schmutz et al., 2015

# Method

## Sampling site

1. Control
2. Along the hydrological gradient
3. Tributaries and confluence
4. Habitat types



Distribution of sampling sites<sup>1</sup>

<sup>1</sup>Schülting et al., 2021

# Method Sampling

**Strip sampling** along the shore  
of larvae and early juveniles  
In spring and summer

## Methodology

- Visual identification
- Combined with fishing



# Method

## Sampling site

Sampling sites with **heterogeneous** structures

### Structure types

- Structured
- Gravel bank
- Bay
- Regulated

### Metric calculation

- Mean abundance per 100m and site

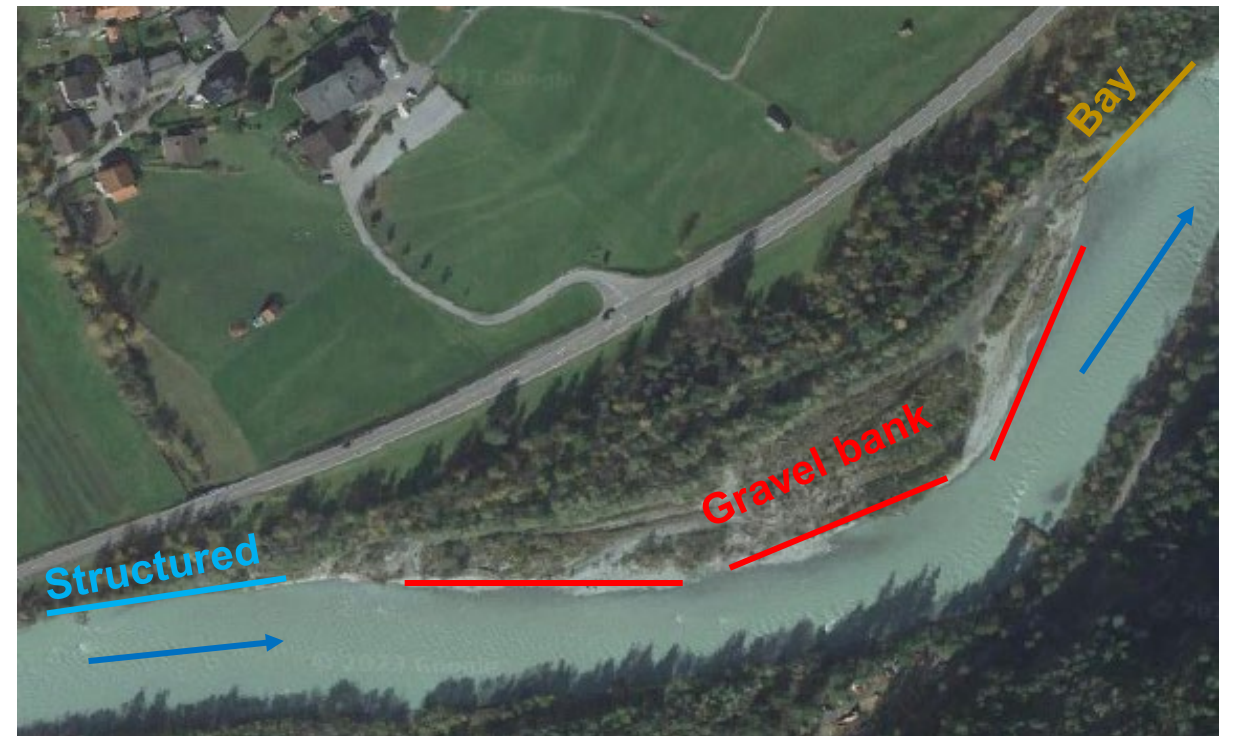
Structured



Gravel bank



Bay





# Results

Hydropeaking category



Difference between hydropeaked and non hydropeaked sampling sites?

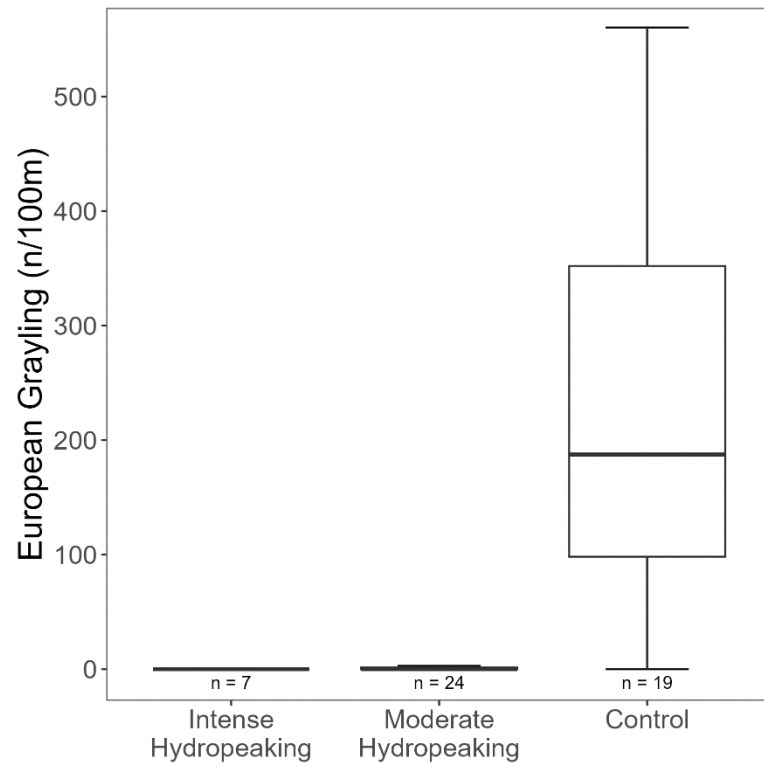
# Results



## Hydropeaking category - European grayling

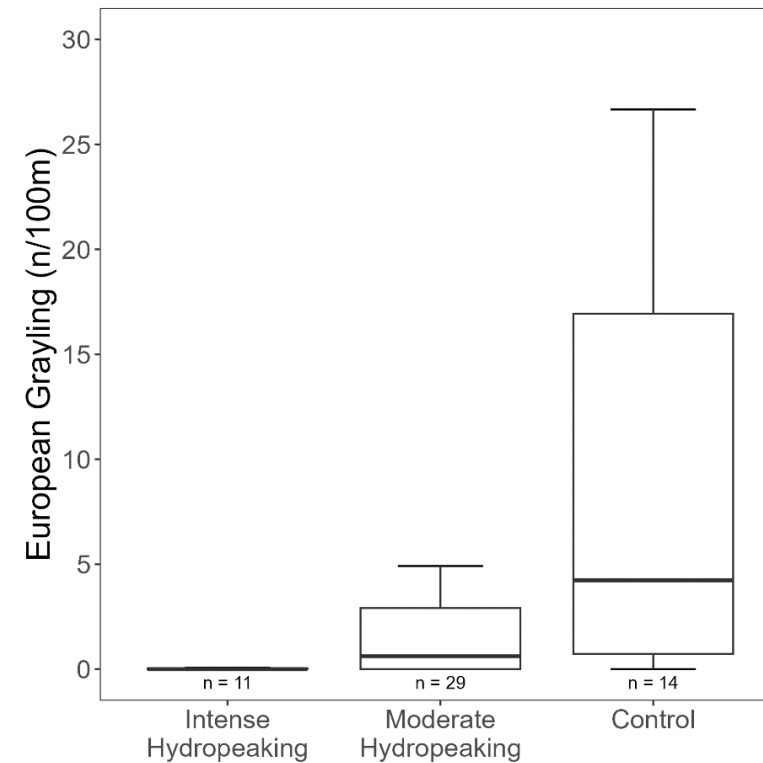
### Spring (April - June)

Pronounced difference between Control and Hydropeaking



### Summer (August - September)

Increase from high intensity to control



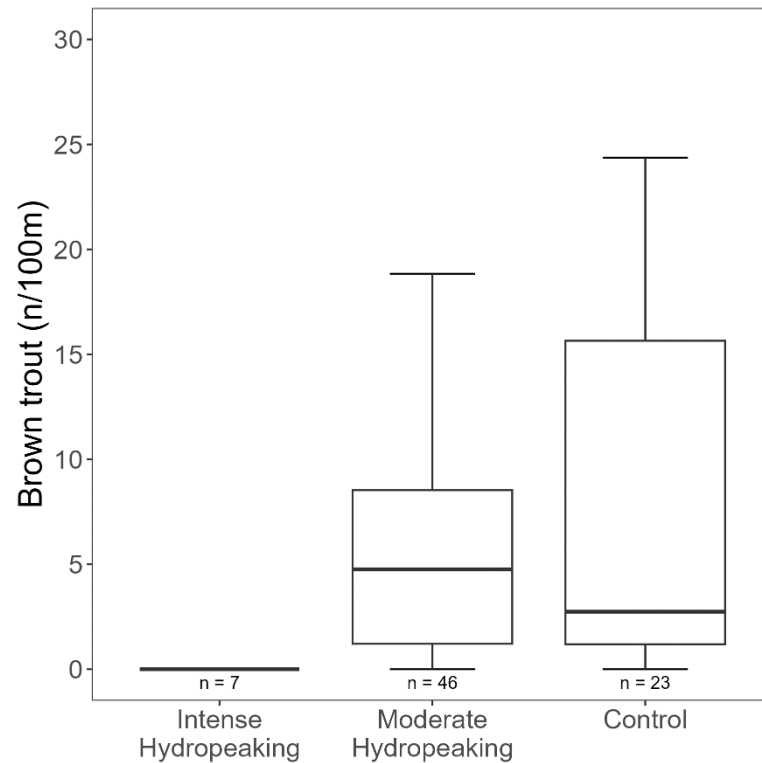
# Results



## Hydropeaking category – Brown trout

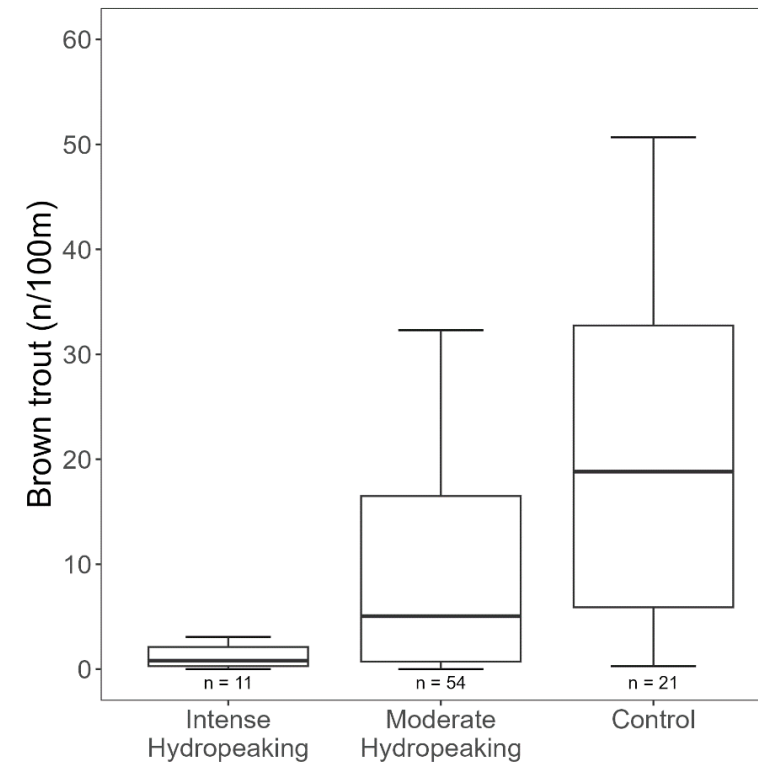
### Spring (April - June)

Only intense hydropeaking shows a clear difference



### Summer (August - September)

Increase from high intensity to control



# Results



## Interaction - Abundance and Hydropeaking

### Biological Metric ✓

*Juvenile fish abundance per 100m  
and site*

### Hydrological Metric?

# Hydrological metric<sup>1, 2</sup>



## Frequency

*Count of events*

- **Amplitude**

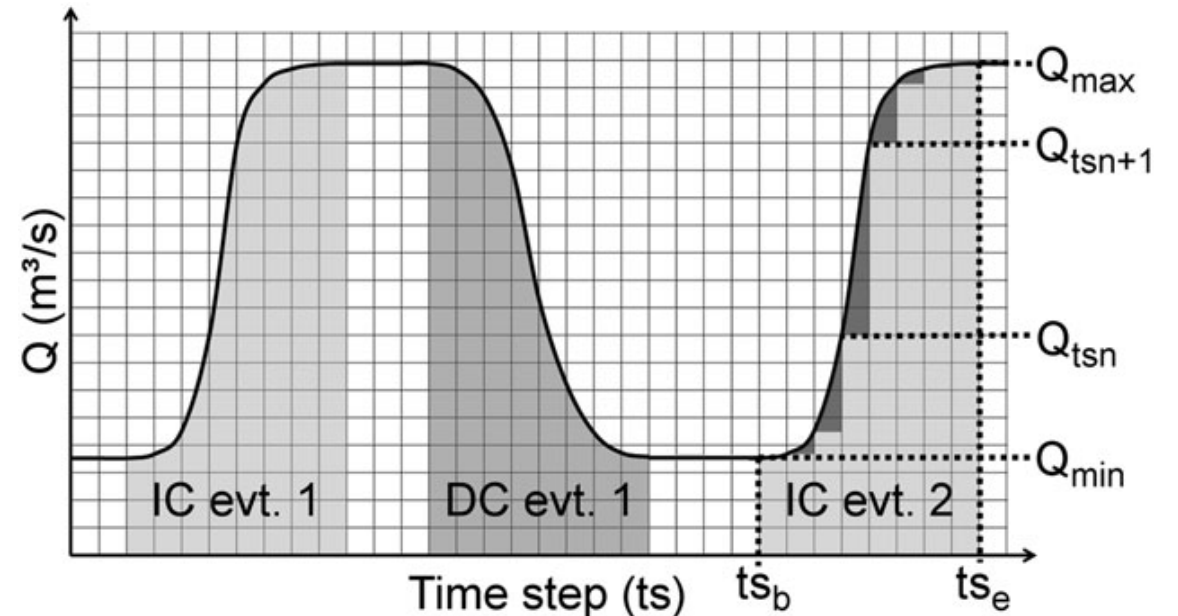
$$Q_{max} - Q_{min}$$

- **Max. ramping rate**

$$\max(\text{abs}(Q_{tsn+1} - Q_{tsn}))$$

## Relevant events

*Threshold: 20% of a natural event<sup>3</sup>*



Hydrological event and fluctuation parameters<sup>1</sup>

Frequency calculated for **multiple time intervals**

<sup>1</sup>Greimel et al., 2016; <sup>2</sup>Sauterleute & Charmasson, 2014

<sup>3</sup>Gremel, 2022 Doctoral Dissertation

# Results

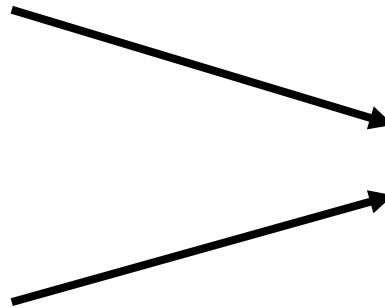
## Interaction - Abundance and Hydropeaking

### Biological Metric ✓

*Juvenile fish abundance per 100m  
and site*

### Hydrological Metric ✓

*Count of hydrological events per  
day and site*



### Interaction?

*Spearman rank correlation  
-> monotonic relationship*

# Results



## Interaction – European grayling - Hydropeaking

**Preliminary results!**

	Time Interval					
Number of ...	7 day	31 days	61 days	92 days	184 days	365 days
<b>...high amplitude events</b>	-0.69	-0.76	-0.76	-0.75	-0.71	-0.66
<b>...high ramping rate events</b>	-0.59	-0.72	-0.66	-0.68	-0.65	-0.60



Highest correlation **one month to three months before summer sampling**

# Results



## Interaction – Brown trout - Hydropeaking

### Preliminary results!

	Time Interval					
Number of ...	7 day	31 days	61 days	92 days	184 days	365 days
...high amplitude events	-0.56	-0.44	-0.48	-0.43	-0.48	-0.55
...high ramping rate events	-0.50	-0.50	-0.53	-0.59	-0.56	-0.62



Not a clear picture for Brown trout



# Discussion and Outlook



1. Fish ecological metrics demonstrate differences between rivers not impacted by hydropeaking and impacted rivers
2. Preliminary results show a correlation between the frequency of hydropeaking waves with high amplitudes and ramping rates
3. Standardised sampling design for pre- and post- monitoring of mitigation measures.
4. Works well for Grayling but not as clear a picture for Brown trout.

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