



Guidelines for hydropeaking assessment in Italy

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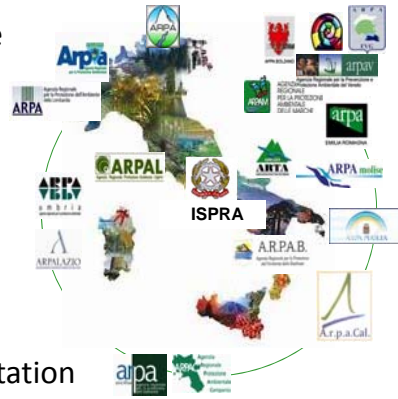
Outline

- National context
- Hymo assessment
- Hydropeaking assessment
- Unexpected benefits?
- Conclusions



Italian National Institute for Environmental Protection and Research

- National Public Body supporting the Ministry of Environment (MoE)
- Research Institute + National Environment Agency
- National coordinator of Regional EA federation
- National WISE node



- Support Environ. policies implementation
- ✓ Produce standards + methodologies for monitoring + evaluation of env. status, flood hazard etc..
- ✓ Make methodologies applicable by competent authorities!
- ✓ Training activity

Institutional context & WFD implementation in Italy



21 REGIONS/P

WFD transpose scales:

- National (star)
- RBD (planning Authorities)
- Regional (monitoring, funding)



2000: DEVOTION

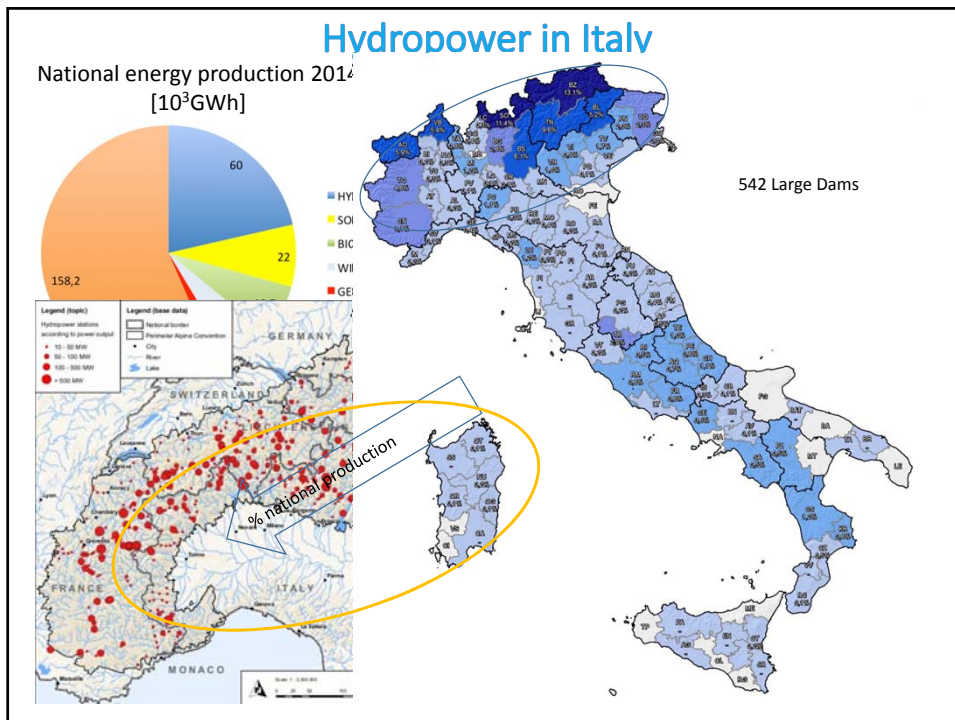


47 UoM (FD)

ed at different

es) River Basin

res, funding)



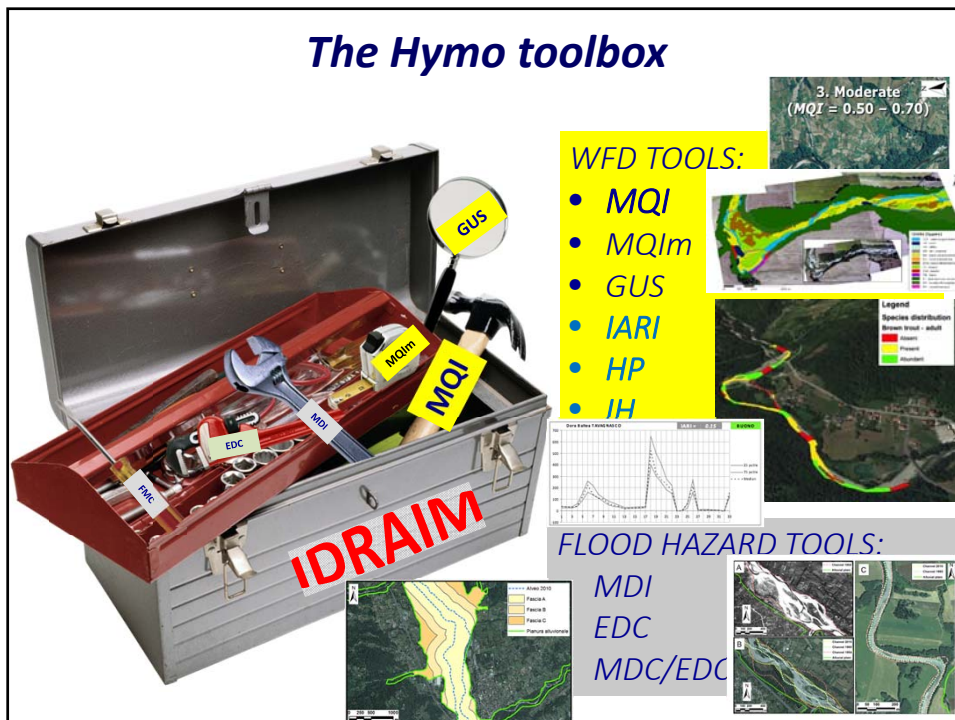
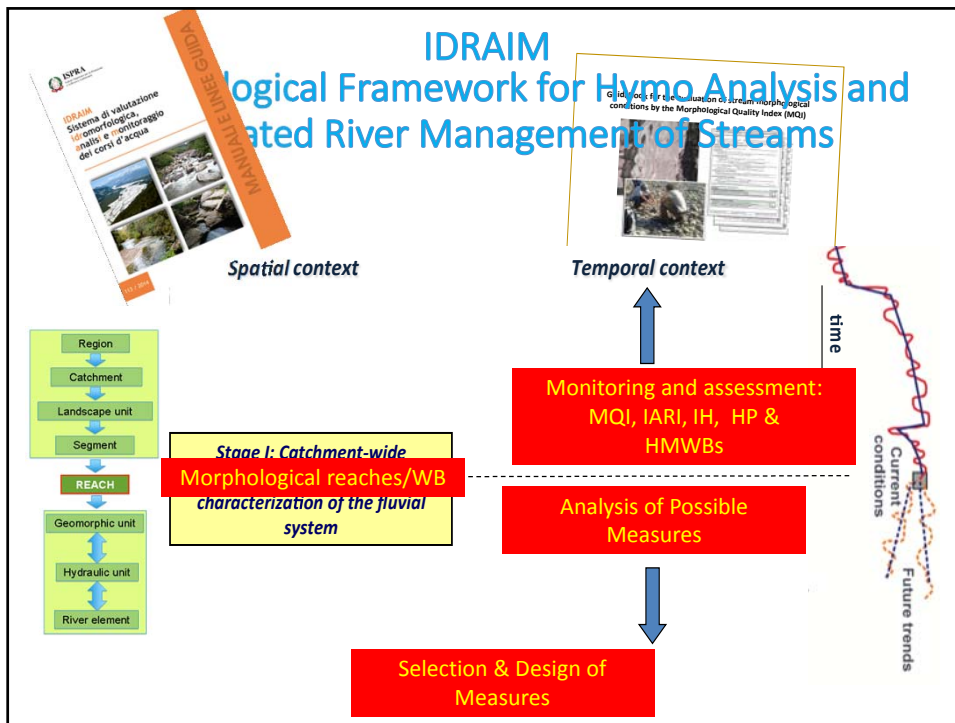
Hymo Pressures on Italian Rivers...

Densely populated country and high levels of hazard and risk related to fluvial processes

Green Energy **Renewable Energy (RES)**
One river, (too) many objectives...?
Multi-scale tools!
Ecological Quality Safety

Magra River catchment

Regione Toscana



WFD Hymo assessment in Italy

Hierarchical evaluations: scaling with the size of the problem/objective.

Morphology (including continuity):

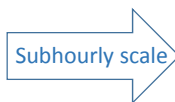
MQI Morphological Quality Index

Habitat Integrity Index (Veza et al. 2014)



Hydrology

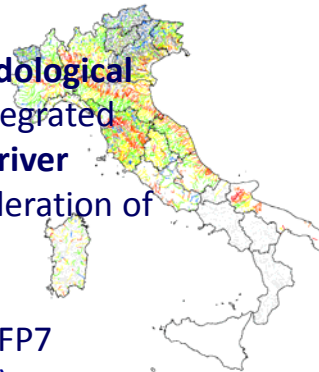
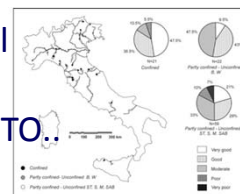
(IARI) Hydrological Regime Alteration Index Based on IHA
(Poff et al, 1996; Richter 1997)

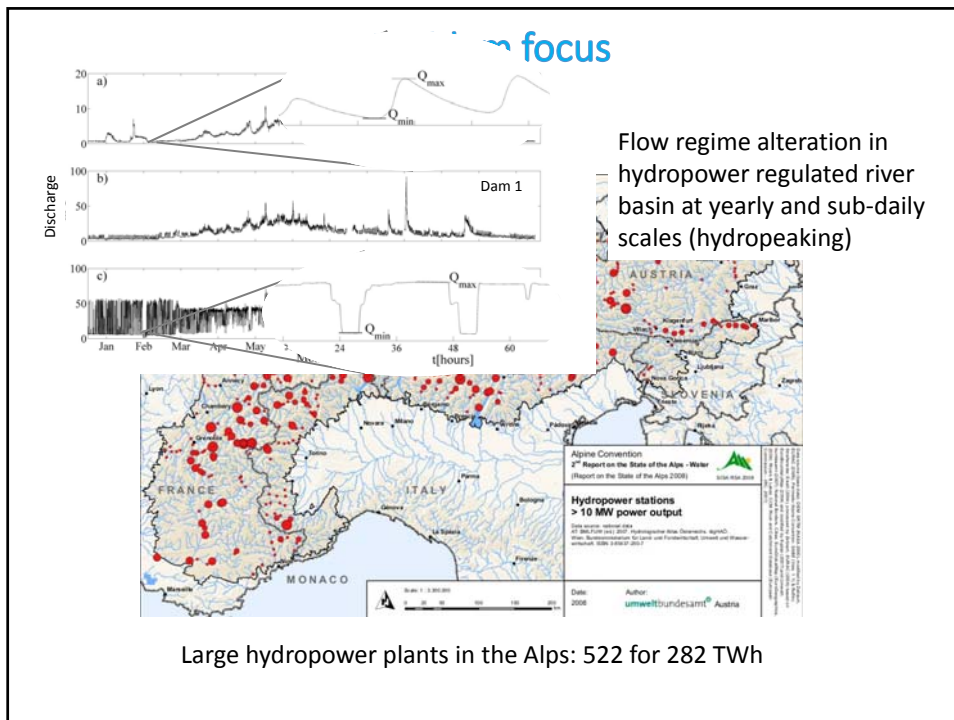


Indicators of Hydropeaking (Carolli et al. 2014)

The road to our hymo assessment approach..

- ISPRA designated by Italian MoE: national Hymo research core group (ISPRA&UniFI+UniTN+UniBZ+UniPD)+PoliTO..
- 2010: WFD HyMo Assessment method **MQI**.
- 2011-2013: **Comprehensive methodological framework (IDRAIM)** to support integrated management of **geomorphological river processes** explicitly including consideration of **fluvial hazard** (2013)
- 2015: Extension to Europe through FP7 REFORM project (**MQI, MQIm, GUS**)





Sub-daily alterations

How much pressure on river reaches?

Application of 2 indicators* to quantify hp pressure

Measure of intensity of hydropeaking
 $HP1_i =$ daily maximum variation of Q

$$HP1_i = \frac{Q_{\max,i} - Q_{\min,i}}{Q_{\text{mean},i}}, i \in [1, 365];$$

$$HP1 = \text{median}(HP1_i)$$

Measure of rate of variation
 (extreme daily ramping and dewatering rates)

$$(HP2_k)_i = \left(\frac{\Delta Q_k}{\Delta t_k} \right)_i = \left(\frac{Q_k - Q_{k-1}}{t_k - t_{k-1}} \right)_i, i \in [1, 365]; k \in [1, \dots, (\text{day} / \Delta t_k)]$$

Population of sub-hourly k rates

$$HP2_i = P90((HP2_k)_i);$$

$$HP2 = \text{median}(HP2_i)$$

k = sampling step

90th percentile as a measure of daily variations (range of variations) to exclude extreme values

Series of daily values as 90th percentile of daily distribution of $HP2_k$ values

* Boillat, J.-L., Schleiss, a. J., & Meile, T. (2011). Hydropeaking indicators for characterization of the Upper-Rhone River in Switzerland. *Aquatic Sciences*, 73(1), 171–182

Hydropeaking thresholds calculation

Thresholds based on a non-parametric definition of outliers were defined and calculated on unpeaked gauging stations data series

$$L_{HP1} = p_{75}(HP1_i^{nat}) + 1.5(p_{75} - p_{25})(HP1_i^{nat})$$

$$L_{HP2} = p_{75}(HP2_i^{nat}) + 1.5(p_{75} - p_{25})(HP2_i^{nat})$$

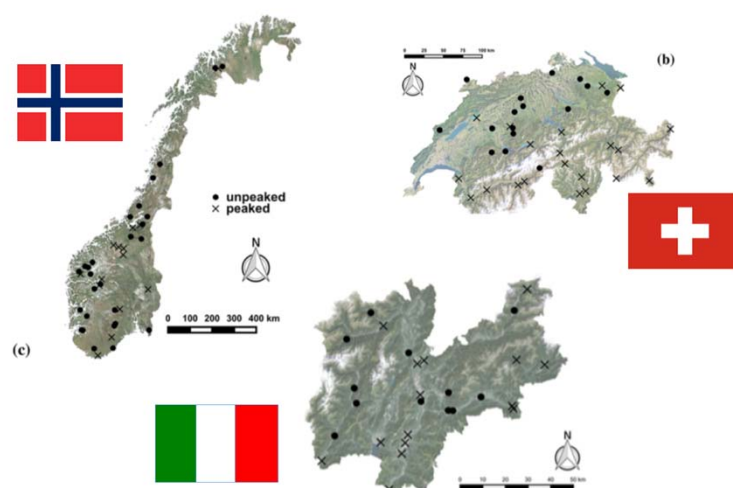
3 classes of hydropeaking pressure

Absent or low pressure: $HP1 < L_{HP1}$ AND $HP2 < L_{HP2}$

Medium pressure $HP1 > L_{HP1}$ OR $HP2 > L_{HP2}$

High pressure: $HP1 > L_{HP1}$ AND $HP2 > L_{HP2}$

Hydropeaking EU






Hydropeaking assessment

It evaluates the level of pressures induced by hydropeaking on a fluvial water body

It is scientifically solid but **easily applicable by the competent authorities**

Aquat Sci (2015) 77:639–653
DOI 10.1007/s00027-015-0408-5

Aquatic Sciences  CrossMark

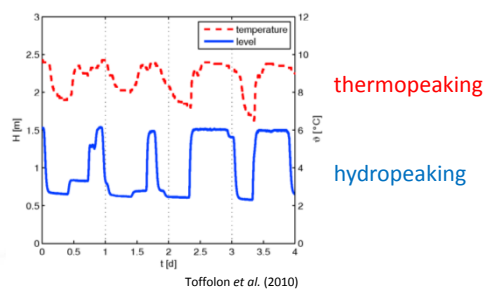
RESEARCH ARTICLE

A simple procedure for the assessment of hydropeaking flow alterations applied to several European streams

Mauro Carolli¹ · Davide Vanzo¹ · Annunziato Siviglia² · Guido Zolezzi¹ · Maria Cristina Bruno³ · Knut Alfredsen⁴

Is that all?

Not only Hydropeaking....



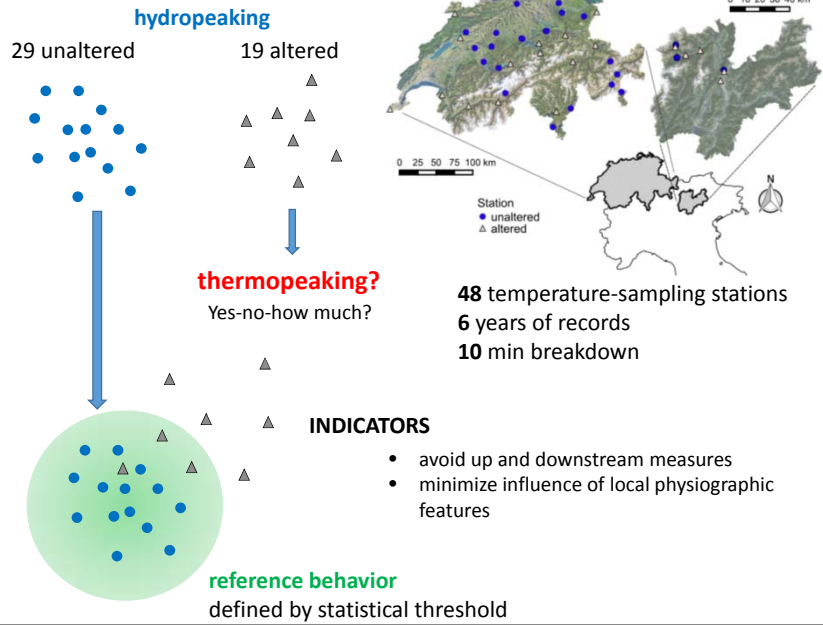
How to recognize thermopeaking from **at-a-station thermal signal**?

Which are the **metrics** heavily affected by TP?

Influence of **seasonality**?

Toffolon et al. (2010). Thermal wave dynamics in rivers affected by hydropeaking. *Water Resources Research*, 46(8), 1-18

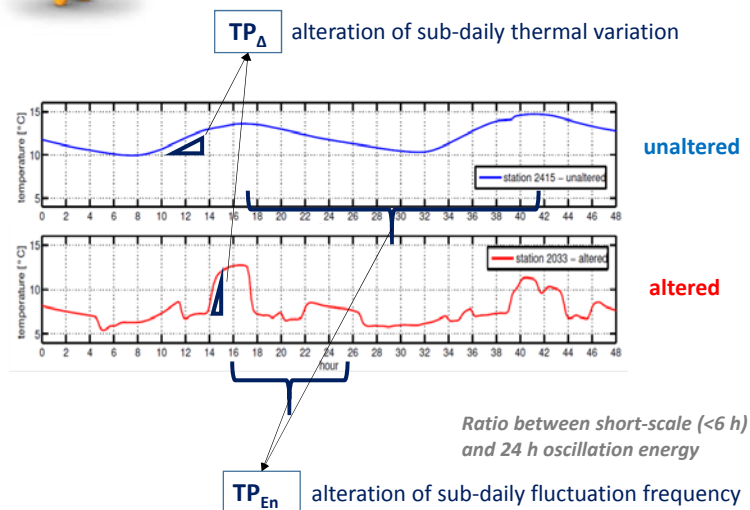
Assessing Thermopeaking: study area



Assessing Thermopeaking: the metrics



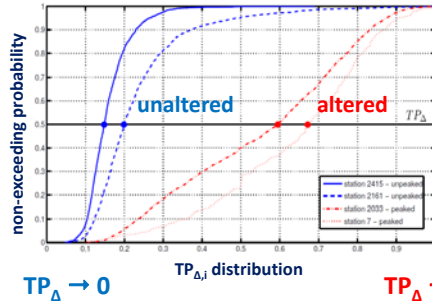
2 different metrics for the sub-daily thermal alterations



TP_Δ

$$TP_{\Delta} = \text{median}(TP_{\Delta,i}) \quad TP_{\Delta,i} = \frac{\max |T_{k+\Delta t} - T_k|}{T_{\max_i} - T_{\min_i}} \sim \frac{\text{max sub-daily variation}}{\text{max daily variation}}$$

median of the ratio between maximum sub-daily (30 min) and the daily variation

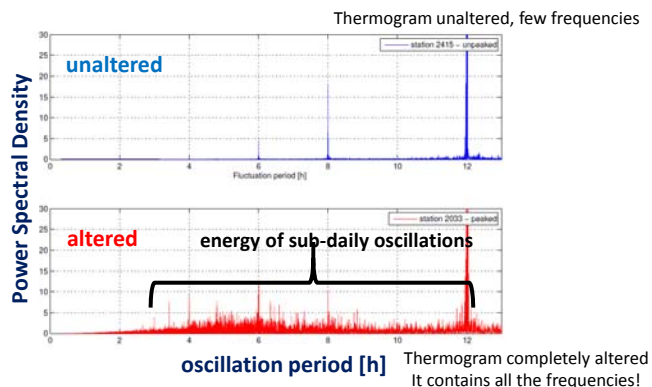


TP_Δ → 0
the maximum sub-daily variation is small compared to daily variation

TP_Δ → 1
the maximum sub-daily variation is similar to the daily variation

TP_{En}

$$TP_{En} = \frac{P_n}{P_{24}} = \frac{\int_{f_n}^{f_s} S(2\pi f) df}{\int_{f_{24}}^{f_s} S(2\pi f) df} \sim \frac{\text{sub-daily oscillation}}{\text{daily oscillation}} \quad \text{Ratio between short-scale (<6 h) and 24 h oscillation energy}$$

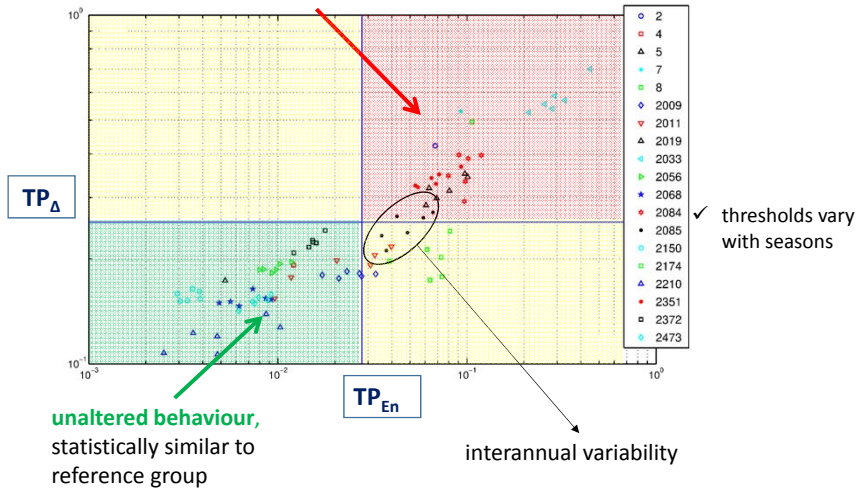
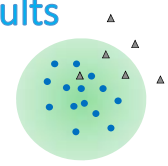


TP_{En} → 0
dominating fluctuation of 24 h

TP_{En} → 1
several short-scale fluctuations

Assessing Thermopeaking: the results

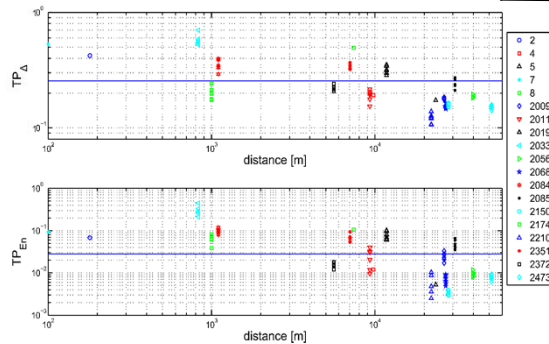
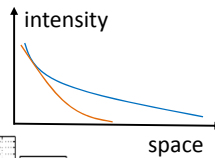
altered behaviour, both magnitude and frequency of thermal fluctuations differ from reference stations



Spatial scale: thermopeaking ≠ hydropeaking?



indicator values decrease with distance



no thermally altered stations further downstream of 12 km from HP release

no relevant influence of physiographic characteristics

- elevation
- basin area
- basin mean elevation
- ...



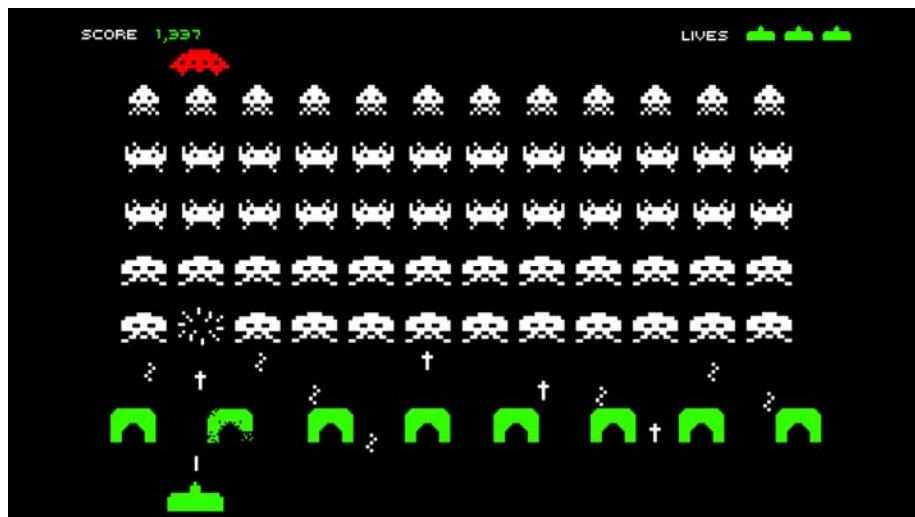
Thermopeaking assessment

summarizing...

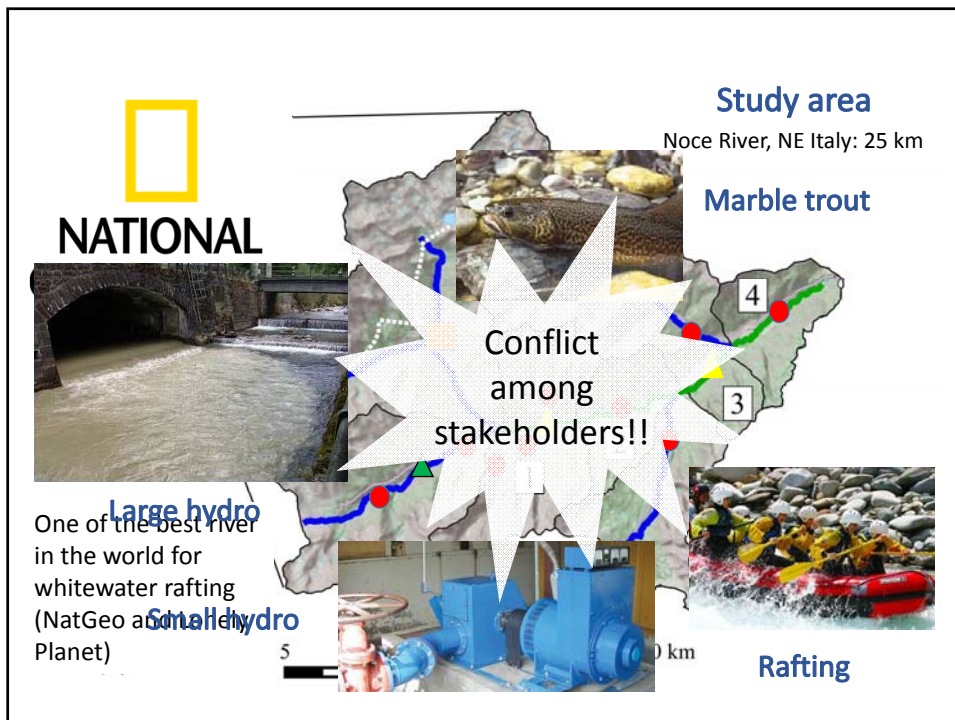
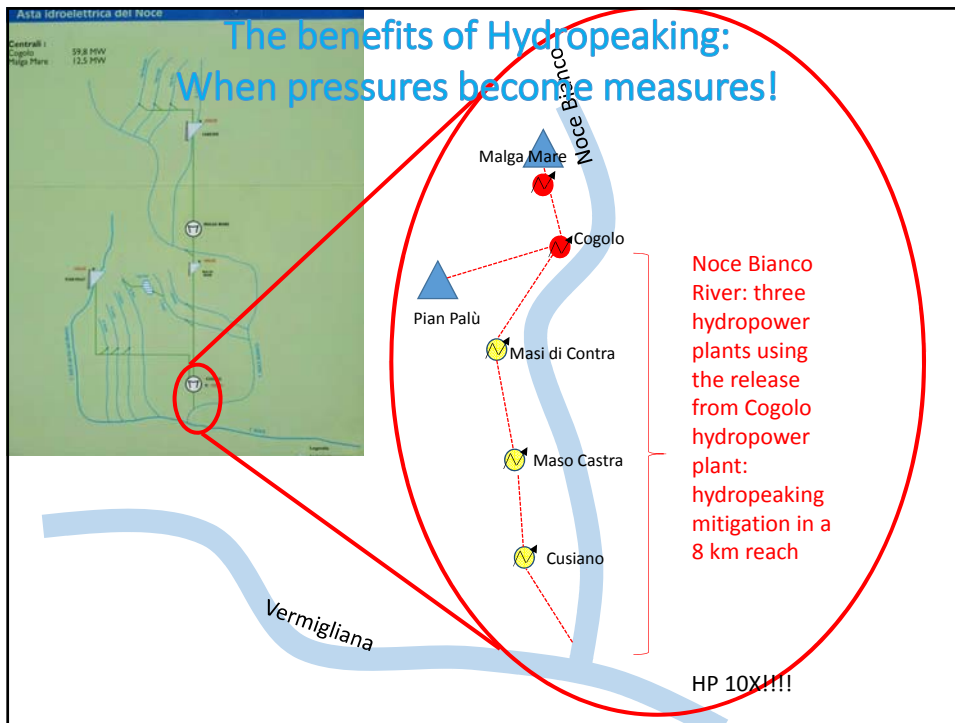
- ✓ define a **reference behaviour** of unaltered stations
- ✓ **statistical approach** to quantify the **sub-daily** thermal regime alterations
- ✓ seasonality: in glacio-nival regimes, **summer** appears to be the most sensitive one
- ✓ TP alterations seem to vanish sooner than HP ones
- ✓ methodology can easily applied (no upstream-downstream measurements required) as **screening tool** to identify thermally altered stations

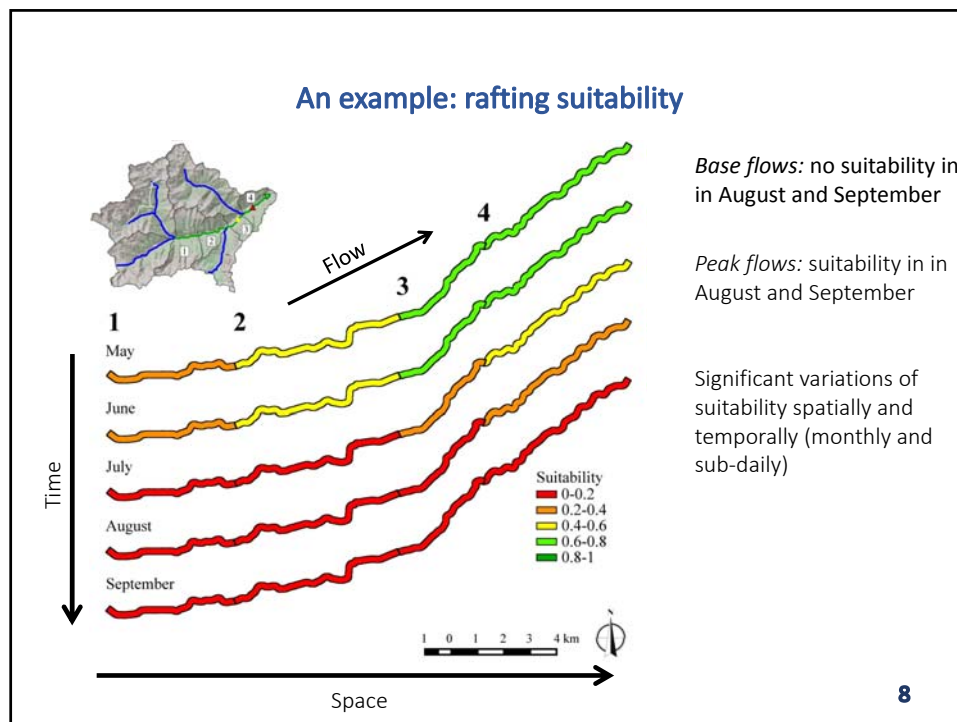
23

Not only Hydropeaking: small invaders!



Decades of hydropeaking...endless demands for licensing.....





Conclusions

- 1) hydropeaking part of multiple stressors due to water uses: diagnosis and mitigation as part of a broader hymo assessment (+ environmental flow measures).
- 2) assessment and design methodologies must be grounded in scientific research, by nature interdisciplinary (ecology, hydraulics/hydrology, geomorphology, ...)
- 3) as part of the increasing regulatory and implementation efforts, hymo & hydropeaking in **Italy** are a central issue not only in research but in the agenda of gov. institutions, competent authorities and hydropower companies

Thank you!

