A WATER FRAMEWORK DIRECTIVE (WFD) COMPLIANT DETERMINATION OF ECOLOGICALLY ACCEPTABLE FLOWS FOR ALPINE RIVERS IN AUSTRIA

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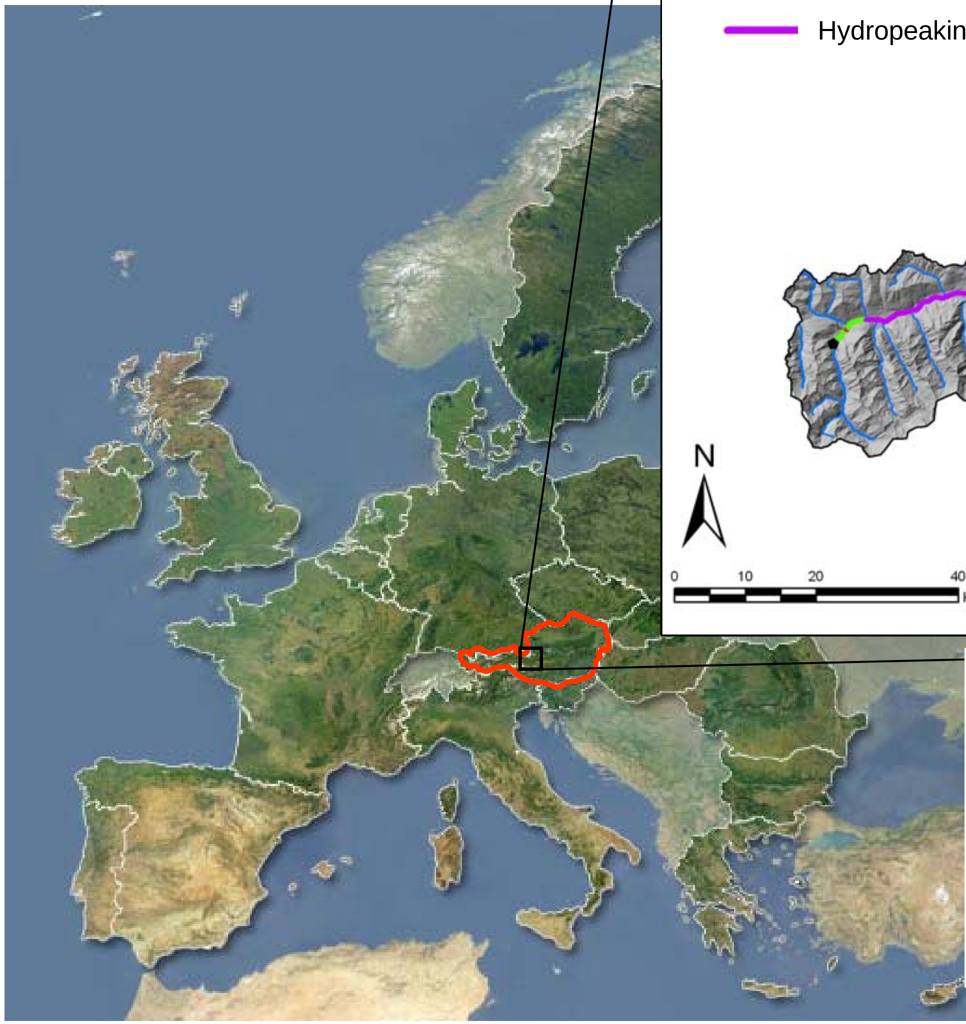
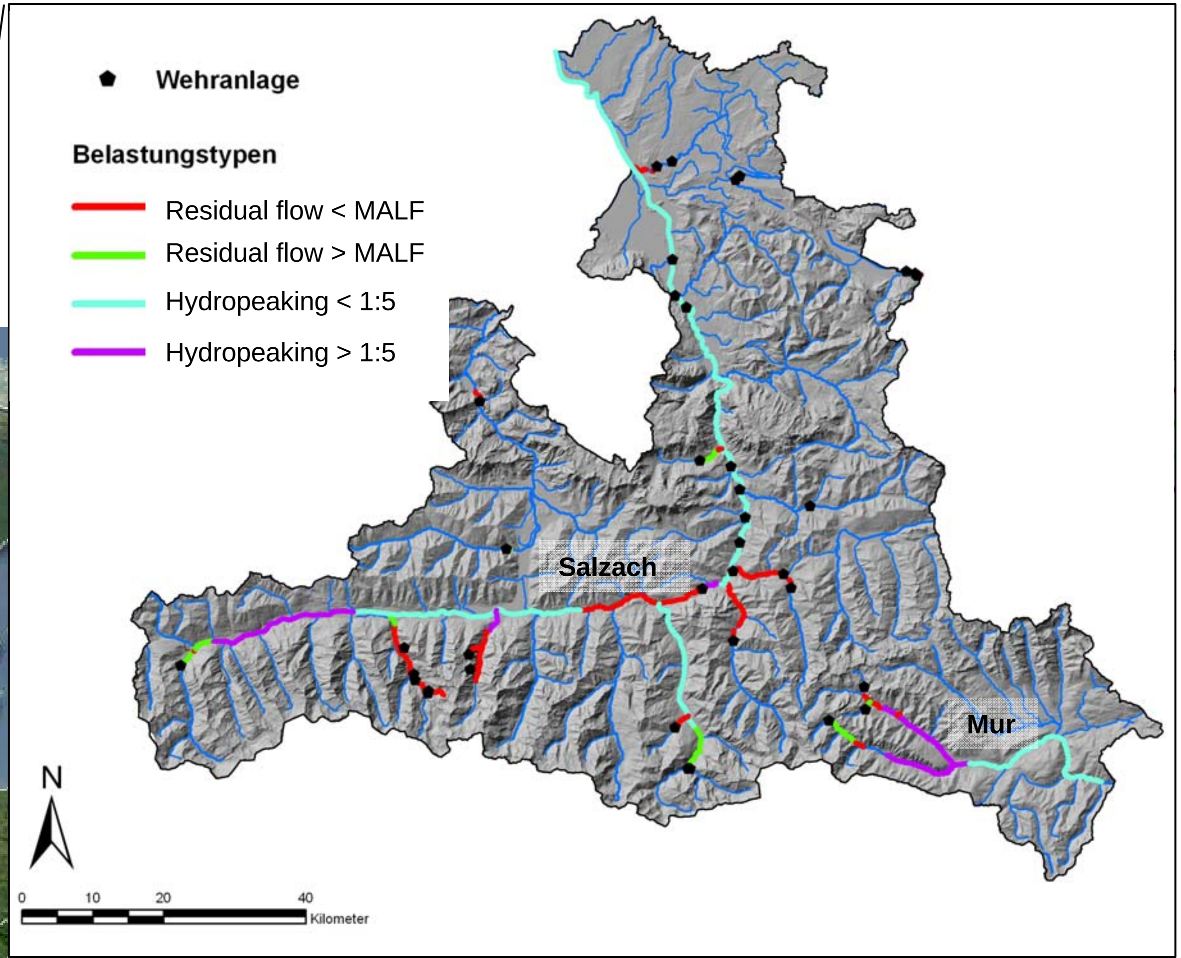
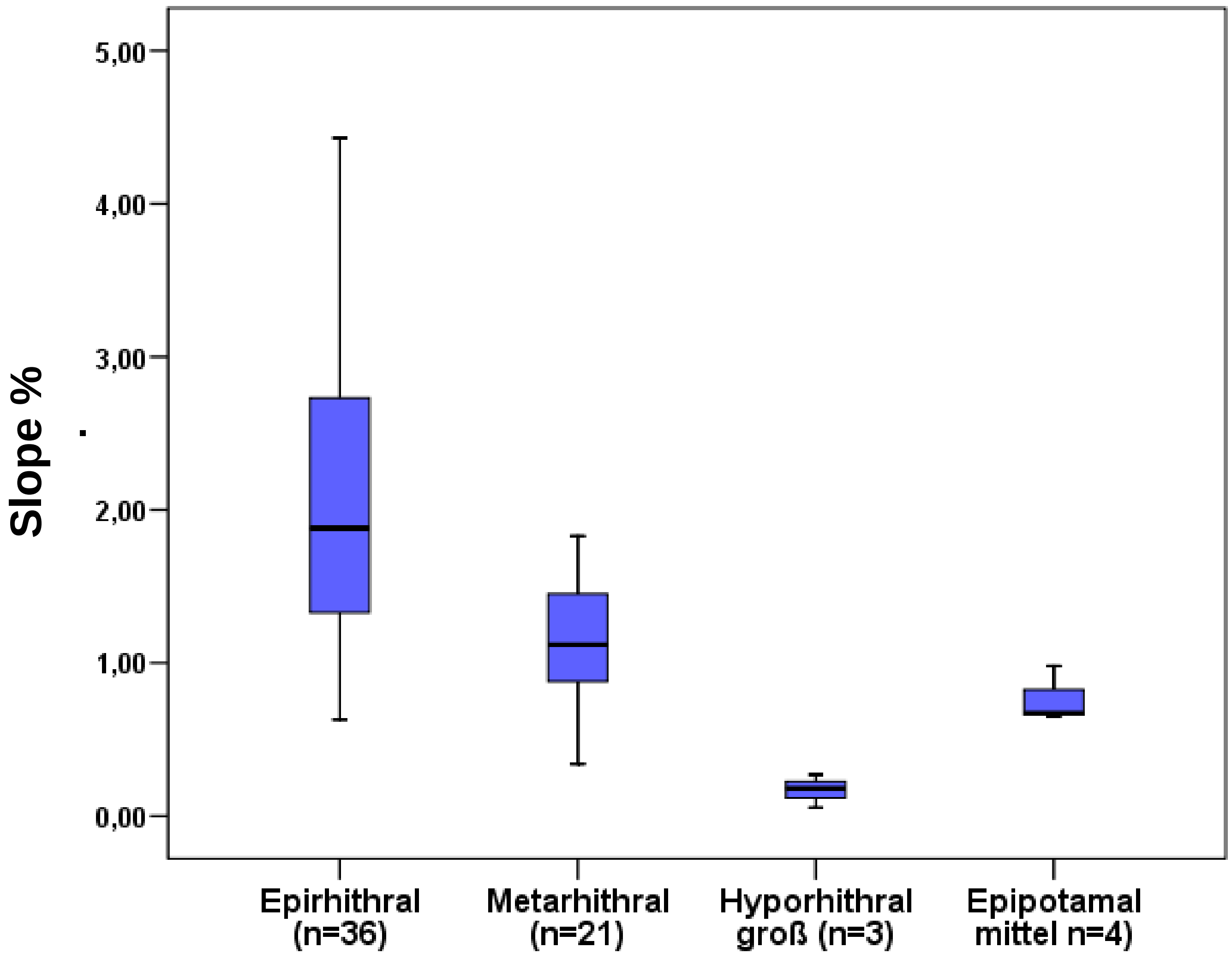
Study sites in Salzburg - Austria





Water abstraction sites at 20 power plants at mainly wadeable rivers at 63 river stretches (40 water abstraction sites, 23 full water sites),

Characteristics of the assessed river stretches



Aim of the study

- **Evaluation** of the existing hydromorphological significance criteria used to pre-classify the **current ecological status** of rivers with regard to the **EU Water Framework Directive** for **macrozoobenthos** and **fish** with regard to:
  - **Ecologically acceptable minimum flow** at water abstraction sites
- **Central question: can the good ecological status (WFD-terminology) can be achieved/maintained when using this significance criteria ?**

Methods

Structure of the residual flow assessment

Significance criteria

- **Ecologically acceptable flow > Natural absolute daily minimum flow (nat. ADMF)**
- **MALF residual > MALF (as total annual discharge load)**

Testing for ecological relevance – is more water needed?

- Fish ecological judgement using Fish Index Austria
- Macrozoobenthos,
- Hydraulic habitat analysis
- Habitat modelling

Testing and validating additional parameters to define the ecologically acceptable flow

- **Maximum depth** in the cross section of the **minimum (“pessimum”) riffle**
- **v_mean** in the cross section of the **pessimum riffle**
- **Mean thalweg depth**
- **Residual pool** depth as a measure for morphology

Additional parameters for determining ecologically acceptable minimum flow

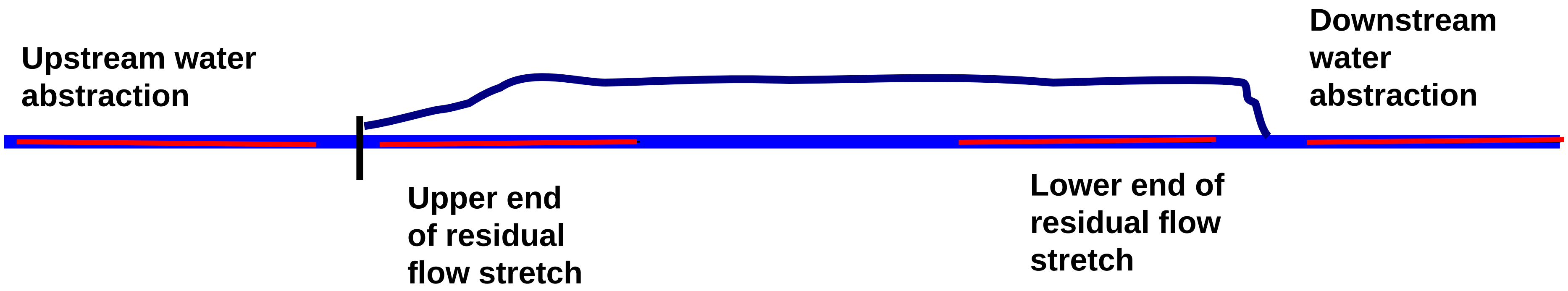
River region	Pessimum riffle		Thalweg		
	Minimum depth (m)	Minimum profile flow vel. (m/s)	Mean depth (m)	Mean depth spawning time (m)	Minimum flow vel. (m/s)
Epirhithral (> 10% slope)	0,10	≥ 0,3	0,15	0,15	≥ 0,3
Epirhithral (3-10% slope)	0,15	≥ 0,3	0,20	0,20	≥ 0,3
Epirhithral (≤ 3% slope)	0,20	≥ 0,3	0,25	0,25	≥ 0,3
Metarhithral	0,20	≥ 0,3	0,30	0,30	≥ 0,3
Hyporhithral	0,20 (0,30[2])	≥ 0,3	0,30 (0,40[2])	0,50	≥ 0,3
Epipotamal	0,30	≥ 0,3	0,40	0,60	≥ 0,3

Measurement & sampling design

Hydraulic & habitat mapping

Fish ecological status (Fish Index Austria)

Macrozoobenthos (Saproby and species specific analysis)

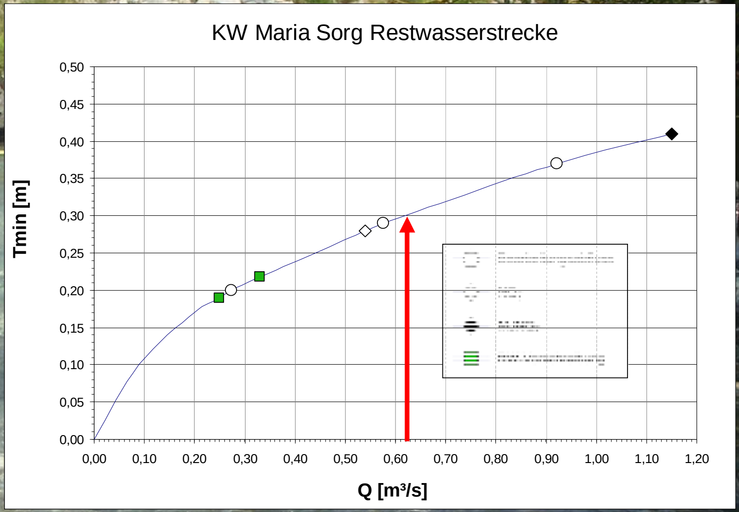


Standard residual flow assessment (Guideline for defining ecologically acceptable flow, Salzburg, Jäger et al. 2008)

Measurements at 200 m sections

- Discharge
- Wetted width
- Maximum depth pessimum riffle
- Mean Profile flow velocity at pessimum riffle
- Pool depths (n=5)
- Riffle depths (n=5)

=> Mean thalweg depth



At three discharges (< MALF, MALF, > MALF)

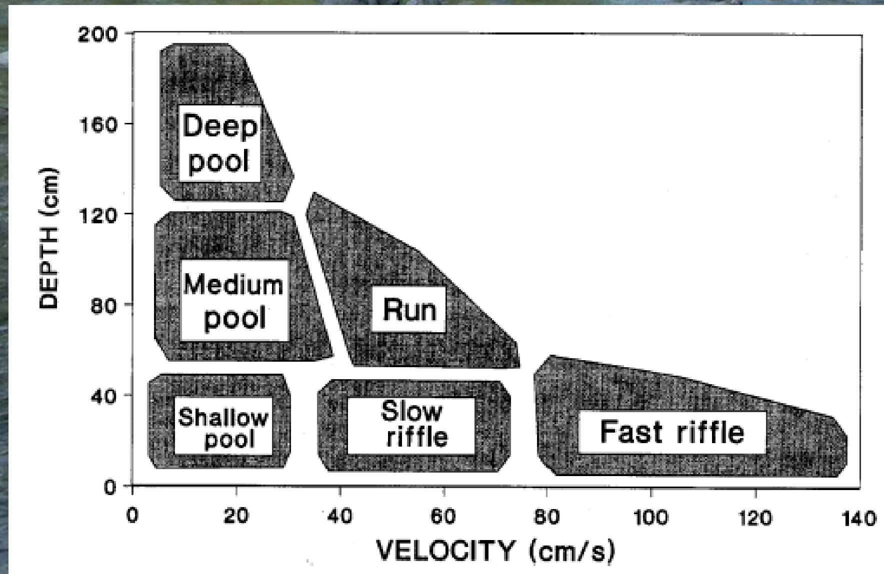
Additional measurements

- Width at MAF
- Bankfull width
- Local slope

Hydraulic mapping mapping (after Parasiewicz, 2007)

Target: systematic and stratified assessment of depth-flow velocity patterns at different discharges- Hydro-morphological units HMU) for orientation and stratification (7-15 measurements per HMU).

Characterisation of instream sediment incl. qualitative assessment of embeddedness and proportion of fines, instream structures (different types - no, existing, abundant), shoreline structure and land use

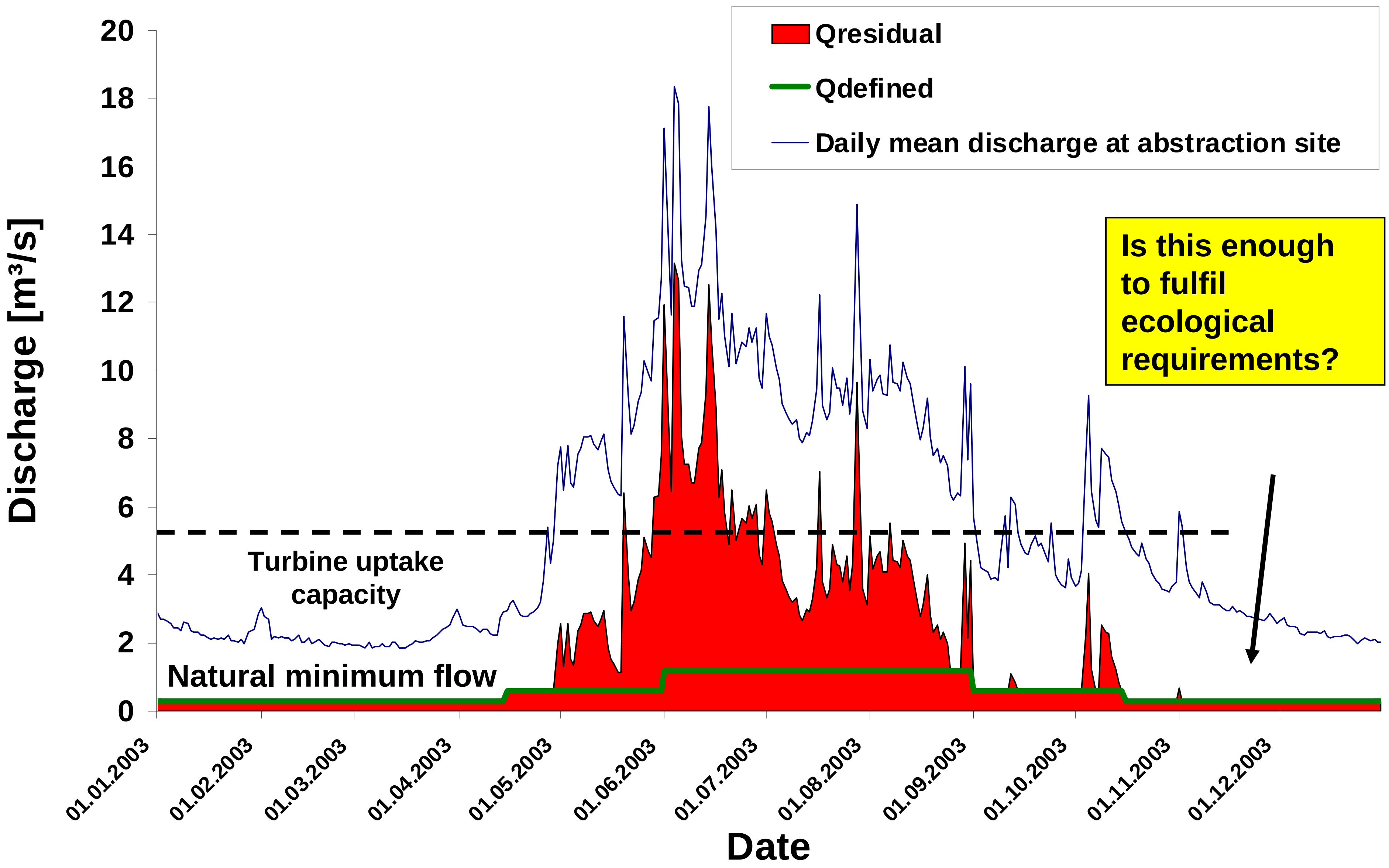


Hydraulic signatures for ecological modelling at different scales, Yann Le Coarer, Aquatic Ecology (2007) 41:451–459

Identification of pressure combinations and main pressures

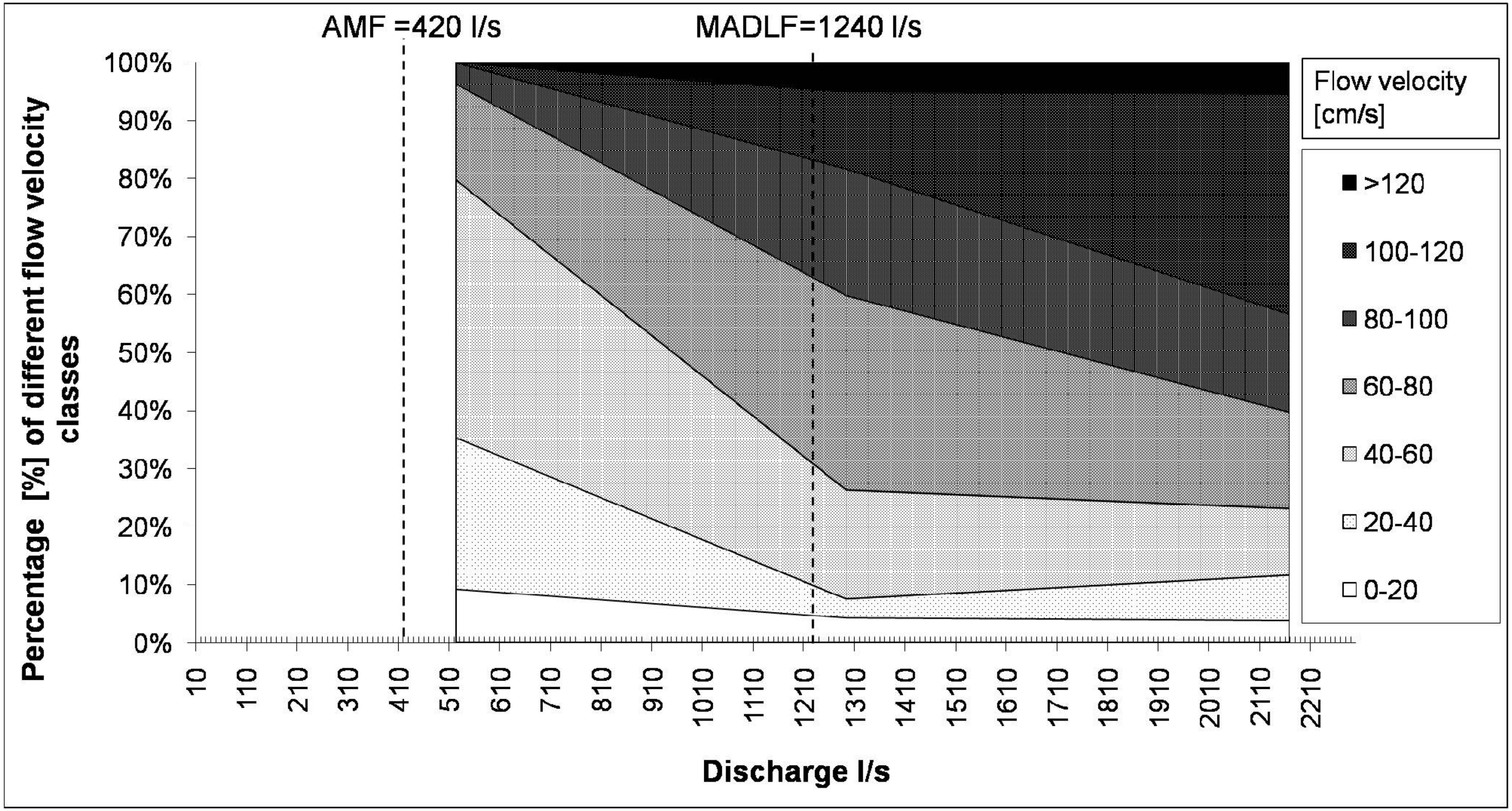
Pressure/Site	Site 1	Site 2	Site 3	Site 4
Water abstraction				
Hydro-peaking				
Morphological change				
Temperature change				
Impoundment				
Connectivity loss				
Embeddedness				
Catchment Land use				
Sediment flushing				
Water quality				

Constructing the hydrograph at water abstraction sites

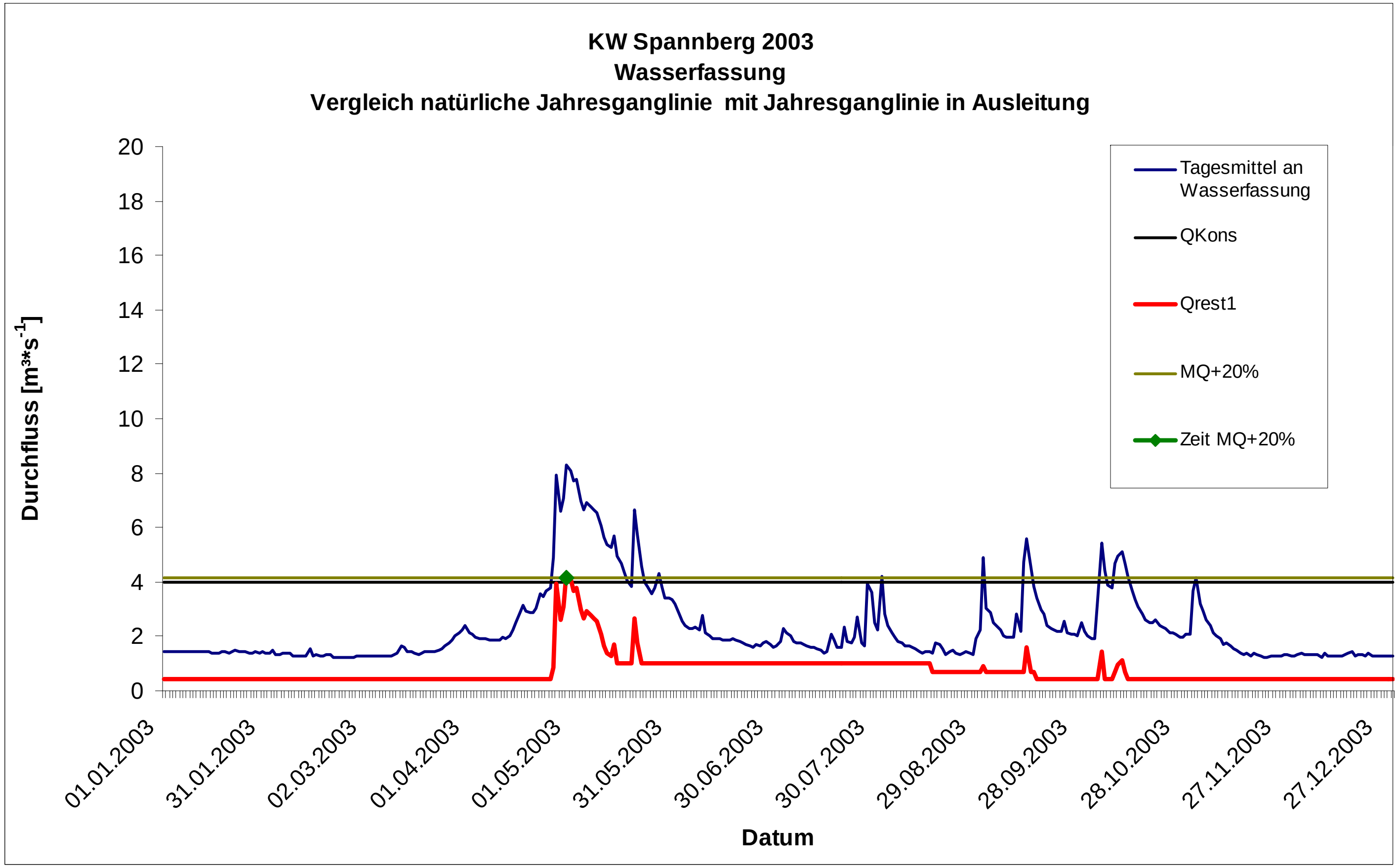


Main results
hydraulic
mapping

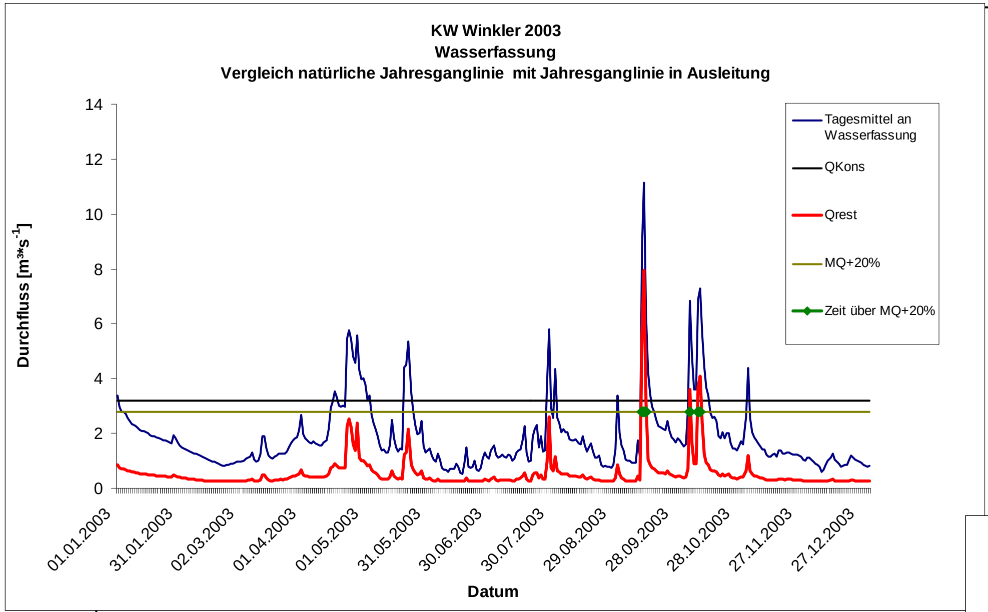
Results hydraulic mapping: Changes of flow velocity distributions with decreasing discharge

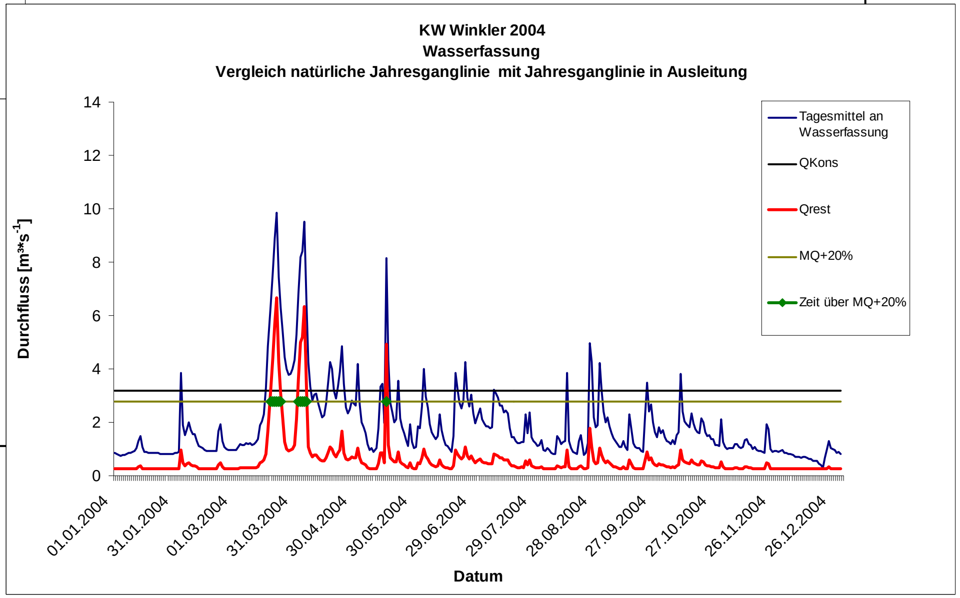


Reducation of substrate moving discharges (MAF+20%)



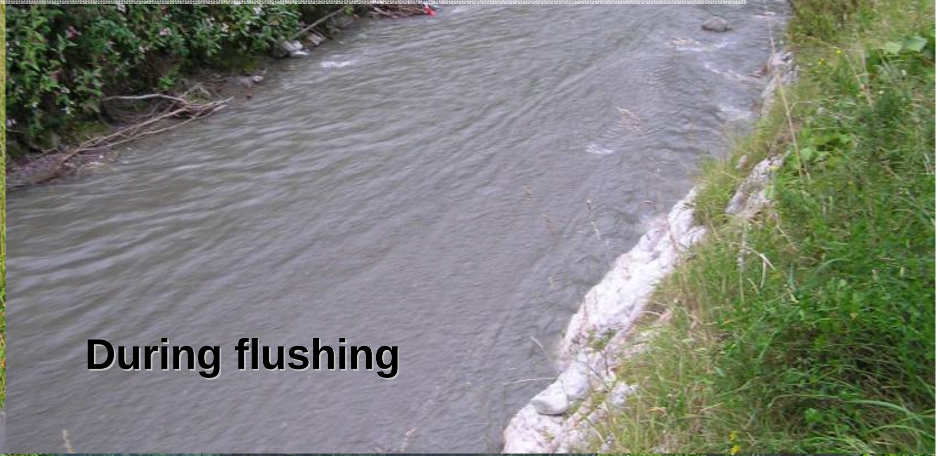
Dynamic discharge in residual flow stretches

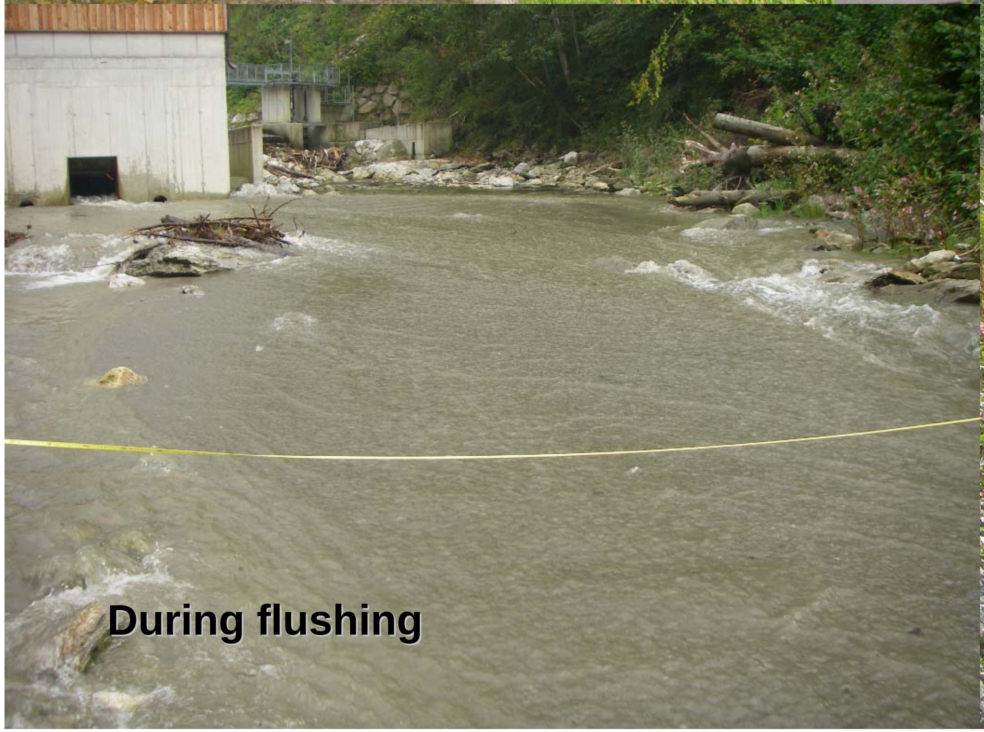




Flushing of sediments from impoundments

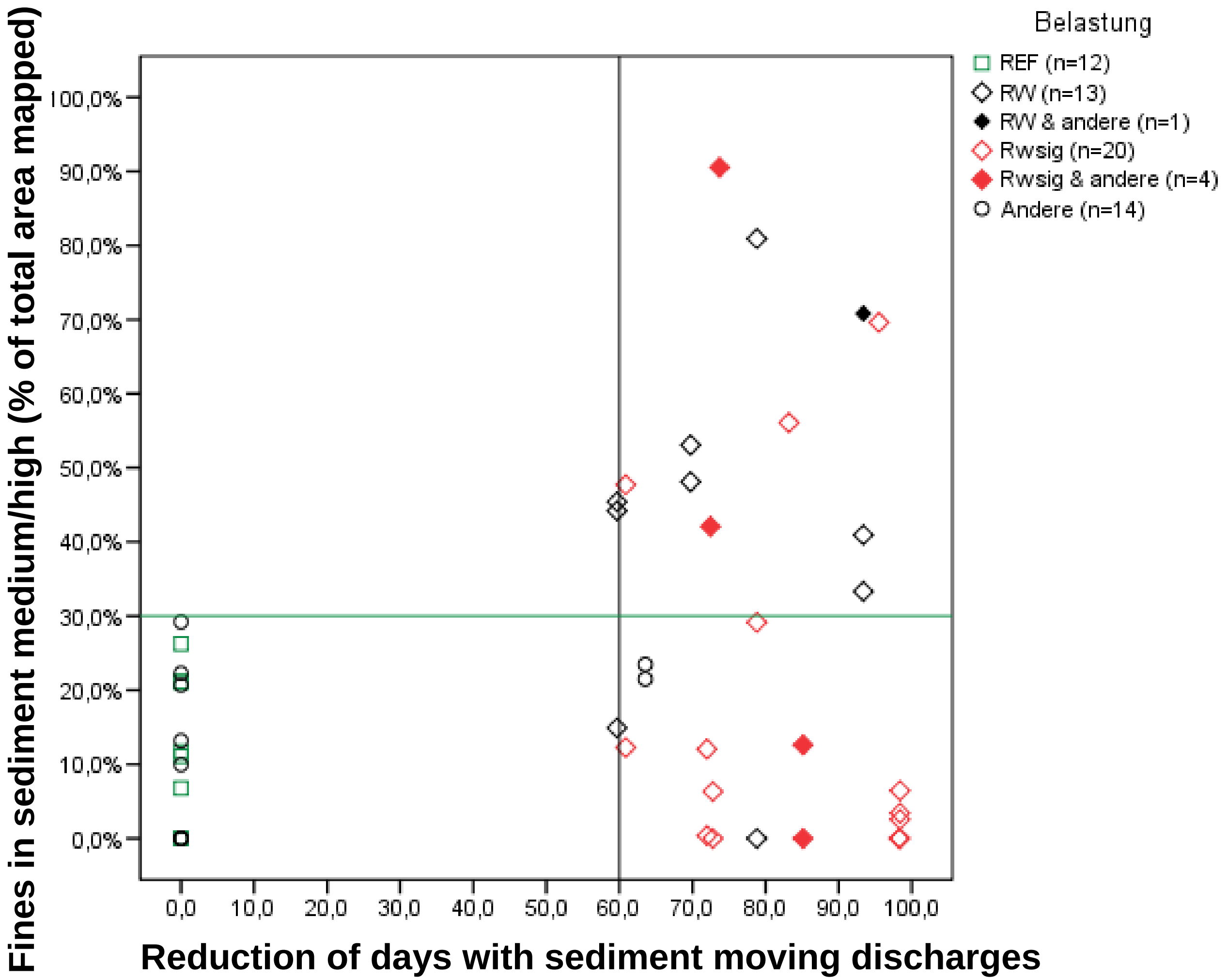

Before flusing


During flushing


During flushing


After flushing

Reduction of substrate moving discharges (MAF+20%) and percentage of area with medium/high fine sediments

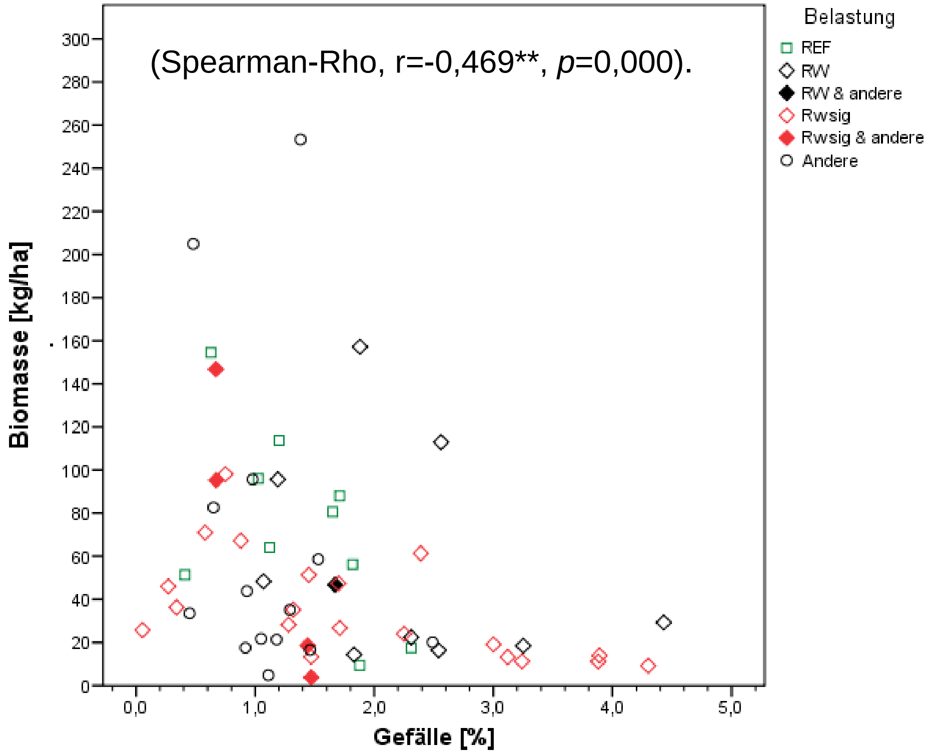


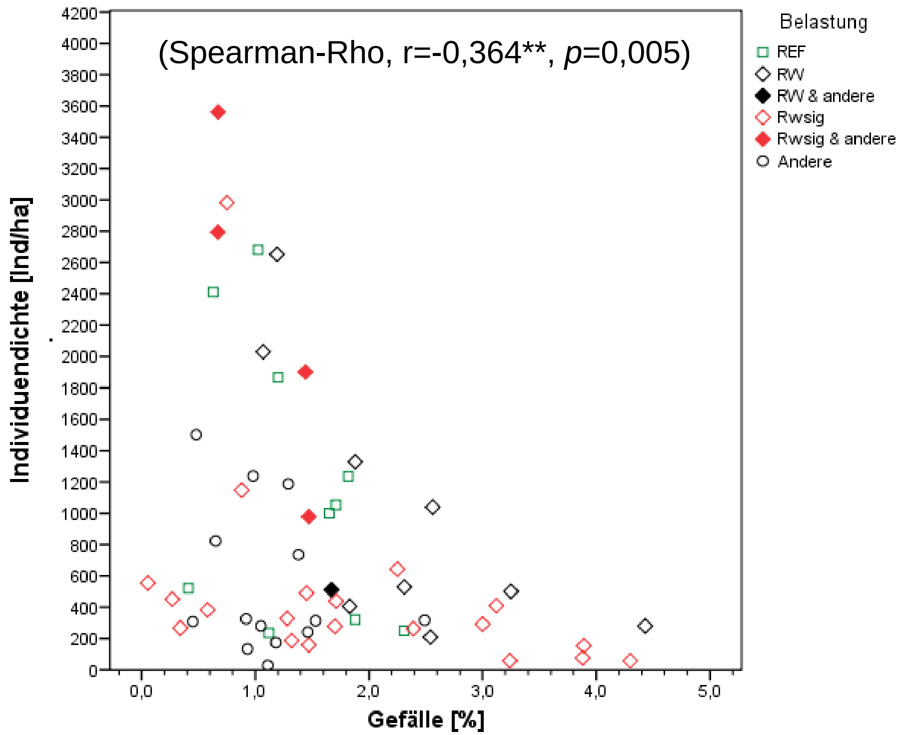
Summary results hydraulic mapping

- **At ADMF** the **highest flow velocity classes** were **lost** in most situations **– maintained above MALF.**
- Below **ADMF** flow velocities between 0,0 – 0,4 became dominant
  - **loss of river type specific flow variability** and **habitats.**
  - **increased sedimentation** of **fines** and
- Below **ADMF** a **significant loss of wetted width** in relation to the wetted width at MALF leading to **significantly reduced ecologically available wetted habitats.**
- Below **ADMF limits** for **connectivity** for fish like **maximum depth** at the **pessimum profile** and **minimum flow velocity in thalweg** are **undercut –** sometimes these parameters **require more** water to be fulfilled!

Main results biology

Relationship between slope and fish biomass

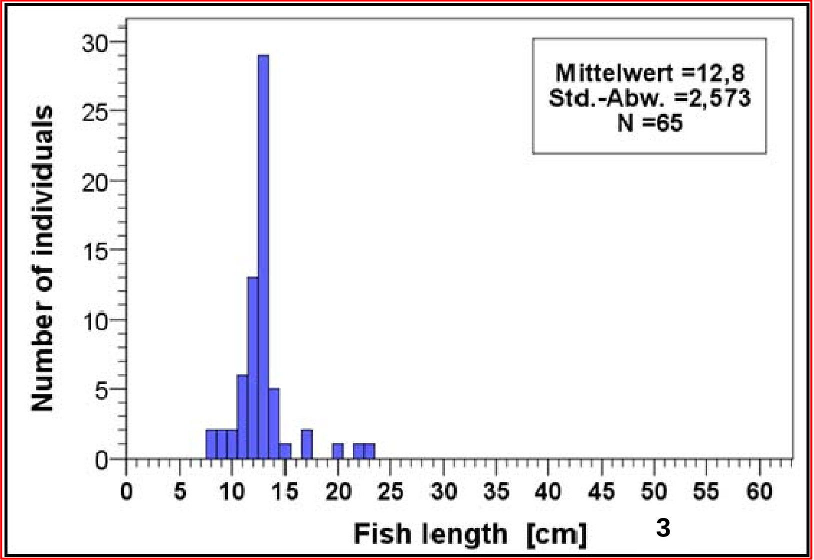


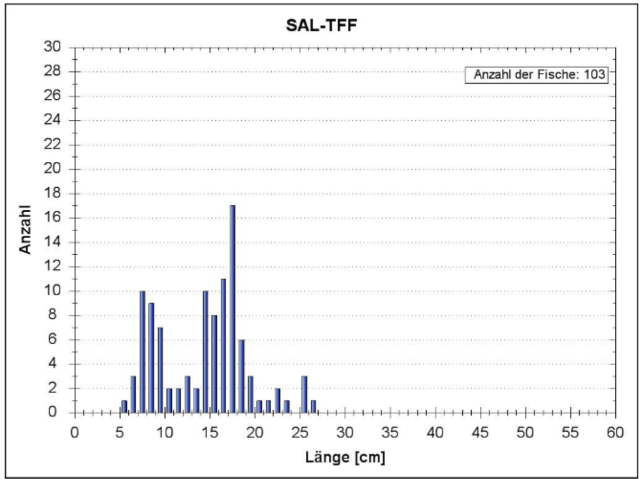


Var_BSST_Q1					,917
Max_BSST_Q1					,915
Var_Fr_Chr_Q1					,905
MW_Var_FG					,892
Var_FG_Q1					,883
MW_gew_BSST_Q1					,842
Max_Fr_Chr_Q1					,828
Max_v_Q1					,794
Gefaelle					,763

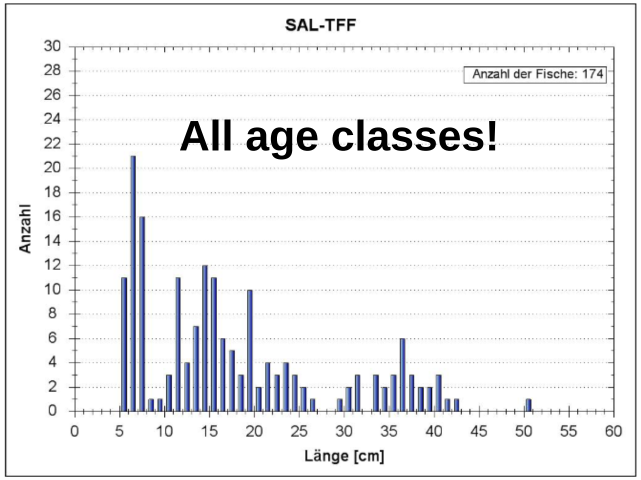
Hydraulic stress as factor highly negatively correlated with fish biomass

Changes in length-frequency distributions of brown trout

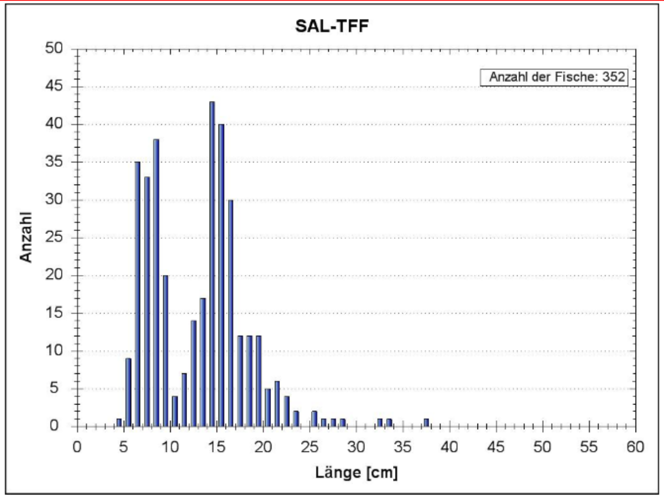




Bachforelle (*Salmo trutta fario*), **2**

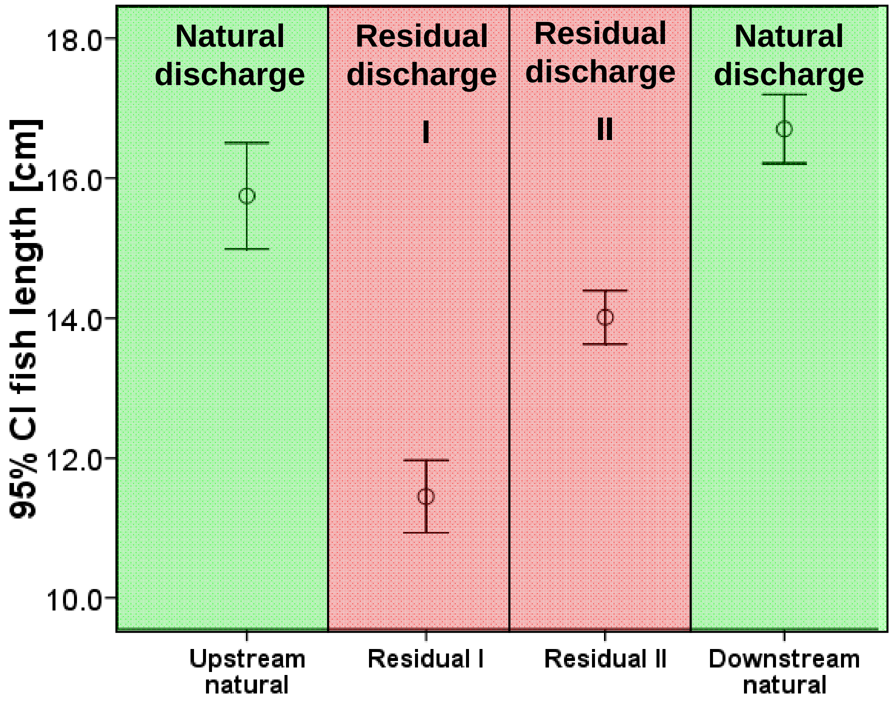


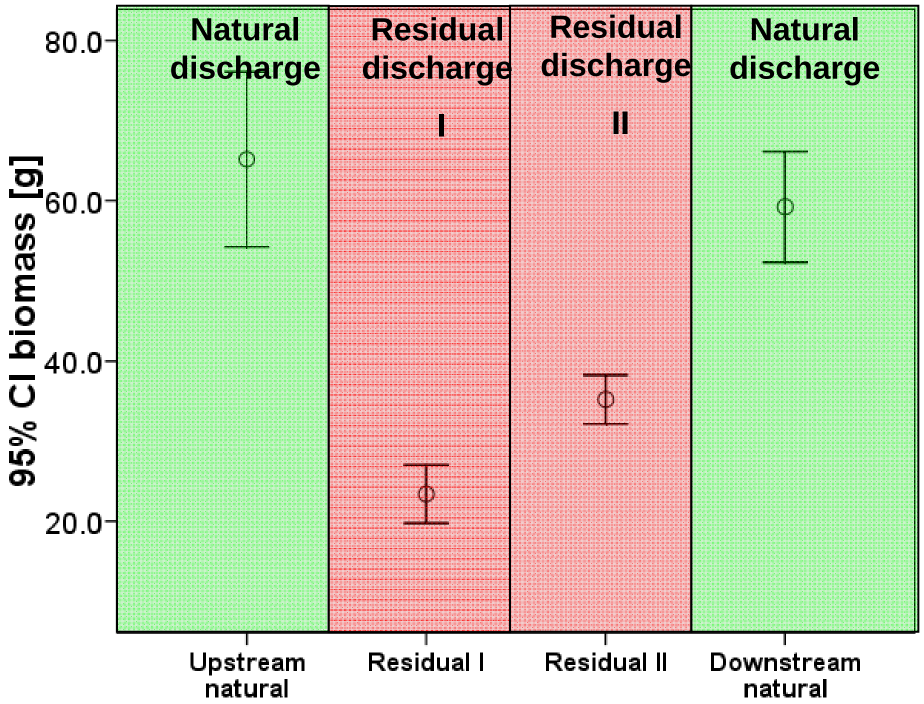
Bachforelle (*Salmo trutta fario*), **1**



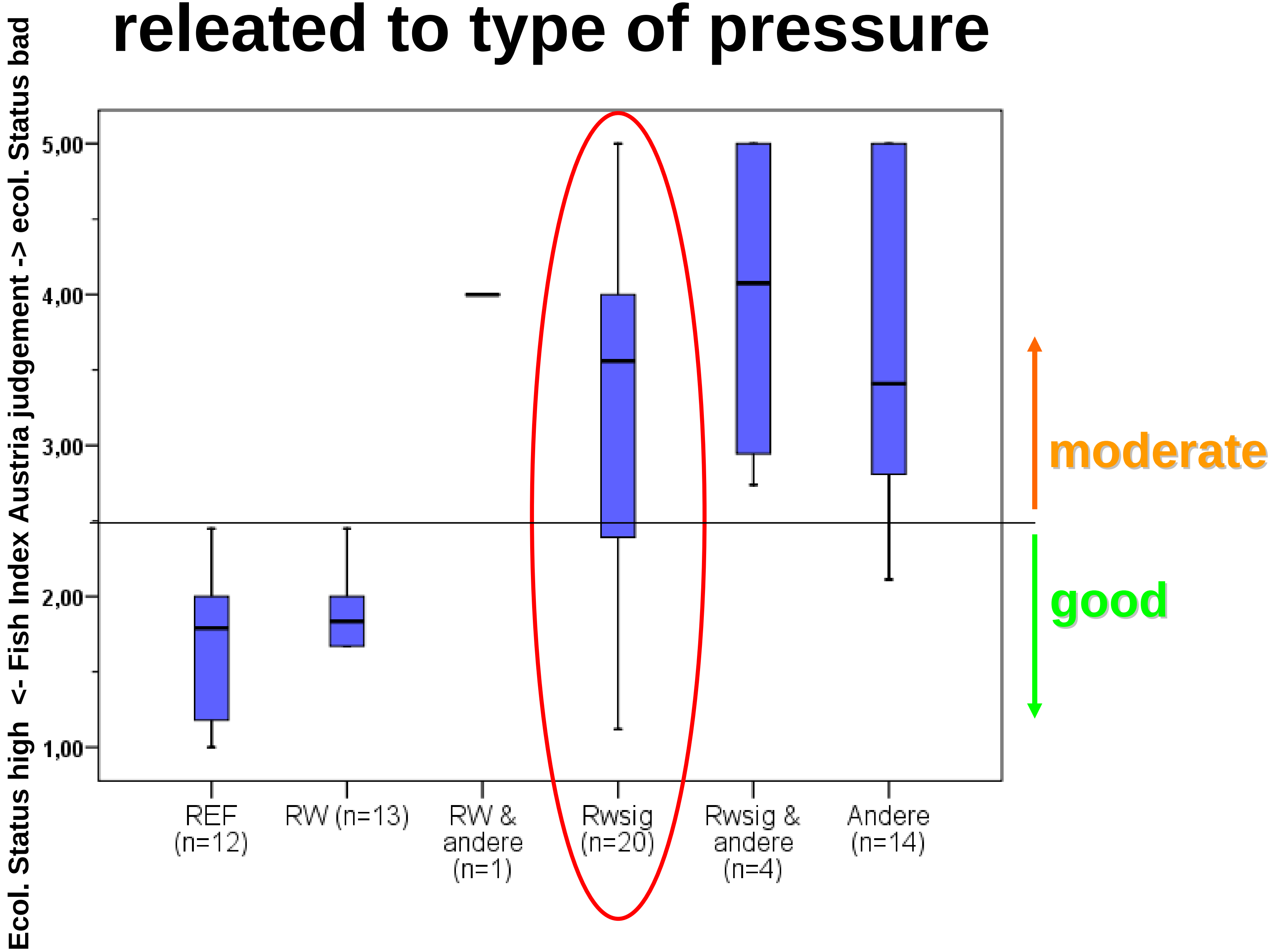
Bachforelle (*Salmo trutta fario*) **2**

Mean length and mean weight of brown trout at natural and residual flow sites

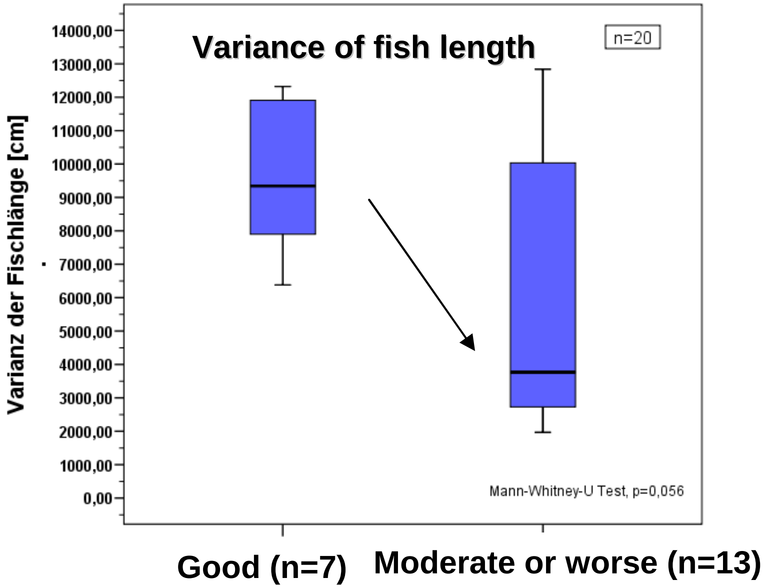


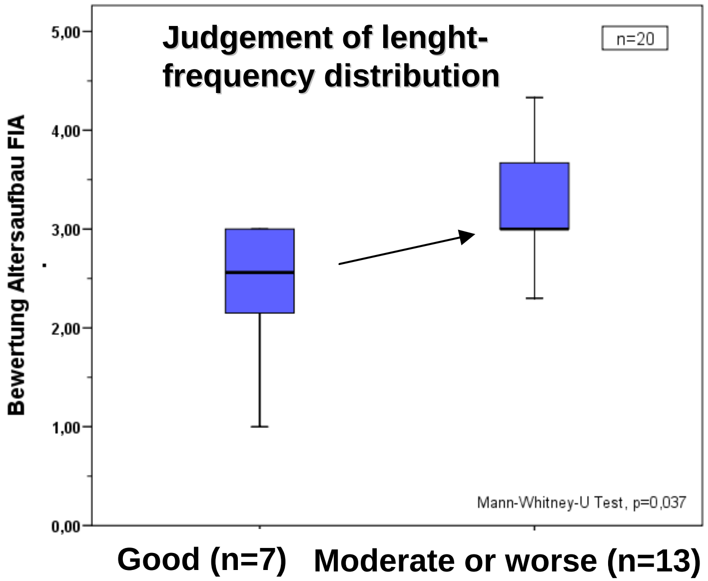


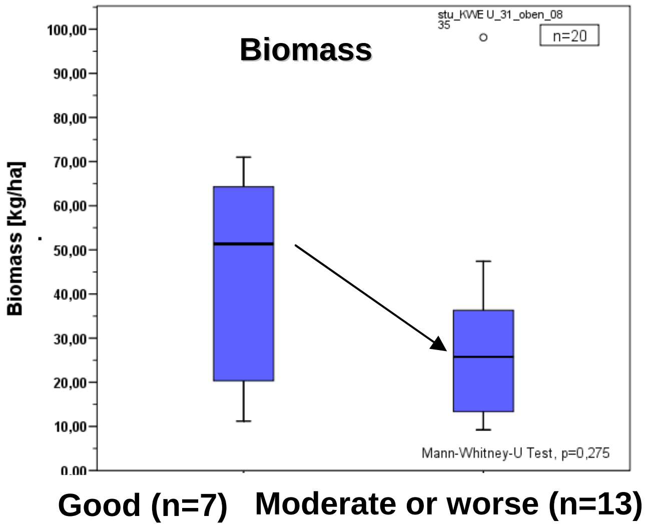
Fish ecological judgement of river sites releated to type of pressure



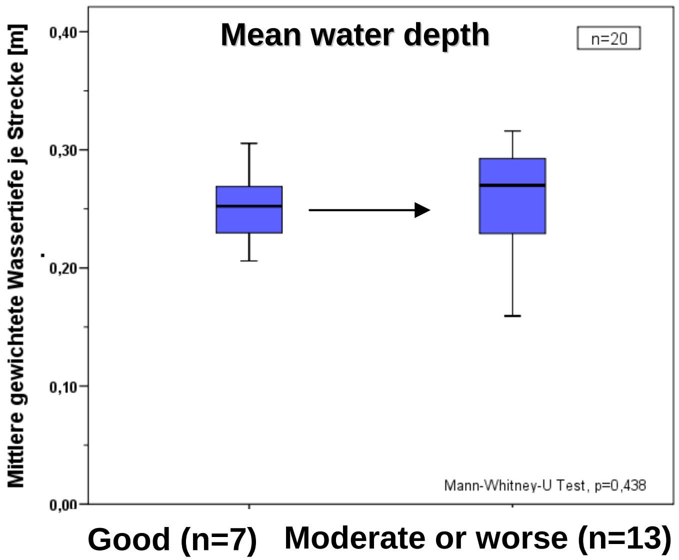
Biotic characteristics in significantly abstracted sites with good ecologcial status

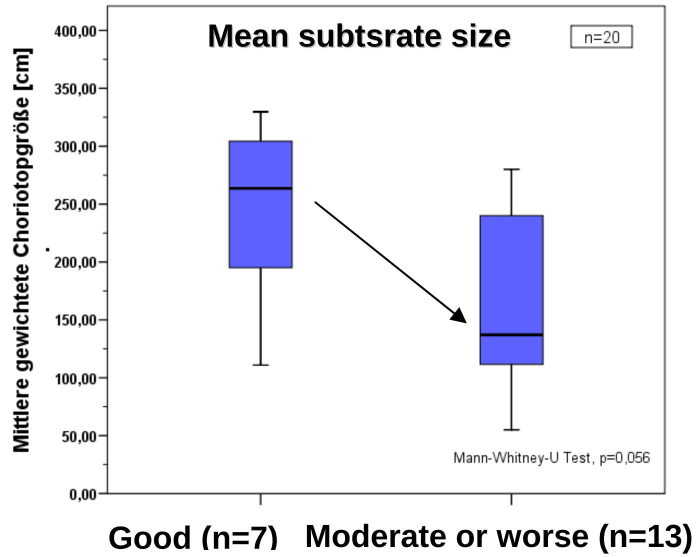


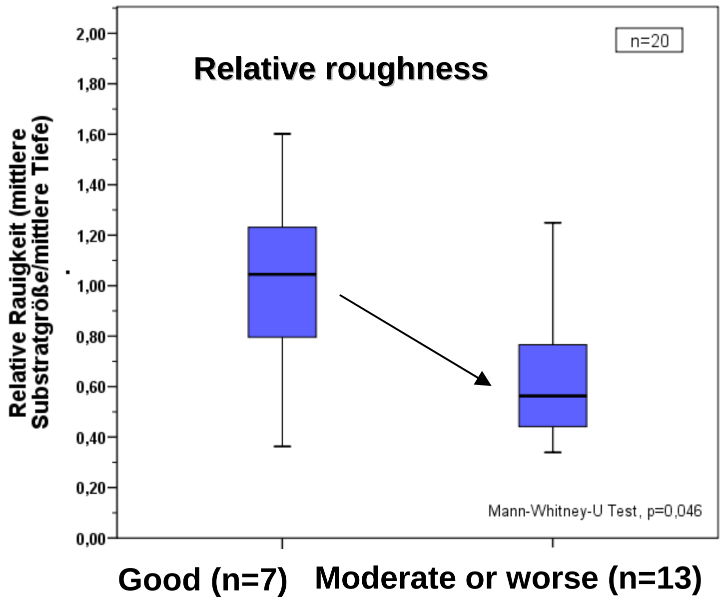




Abiotic parameters explaining the good ecological status at significantly abstracted sites



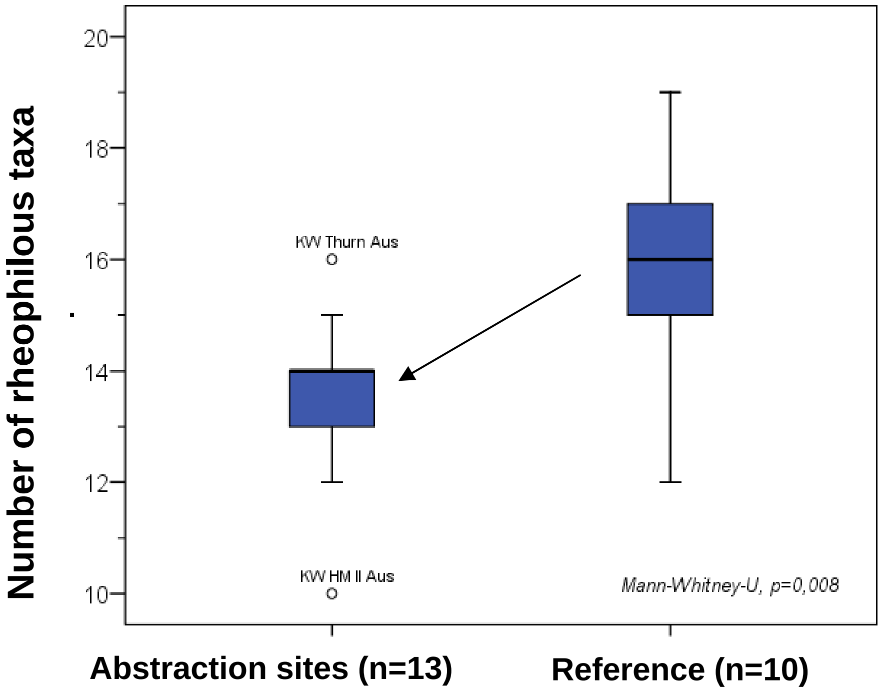


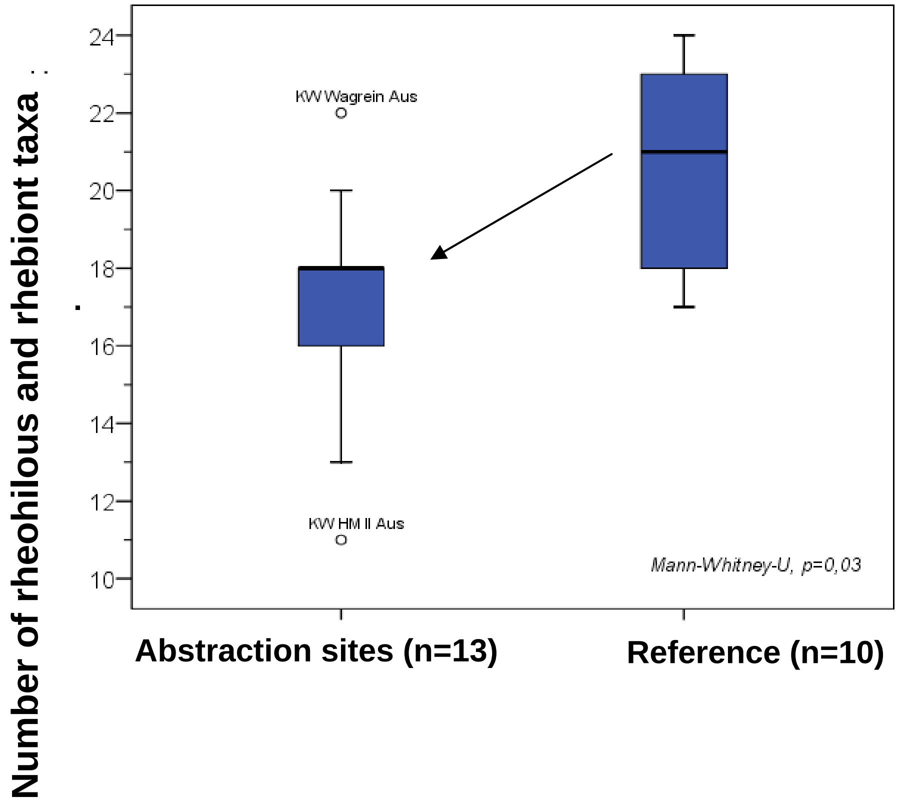


35 % of significantly abstracted sites with good ecological status

- Situated in **smaller and steeper rivers**, with two of them being situated **at the upper end of the fish bearing zone**.
- Situated within the trout region with **brown trout being the only dominant species**.
- **Larger mean choriotope size** lead to higher values of relative roughness -> habitat heterogeneity -> different size classes of trout -> higher variance of fish lengths -> **better judgement of the age distribution**.
- The **biomass** was always considered as **satisfying** and biomass KO criterion was never actuated.

Results Macrozoobenthos – reduction of rheophilous species





Saproby Index failed to assess the impact of water abstraction on ecological status!

Conclusions

- **ADMF** represents a **valid base for determining the ecologically acceptable base flow -> additional parameters help to maintain important functions like connectivity.**
- **Experiences:** in **steep alpine rivers** in some cases its hard to **reach the cut value for minimum depth (15-20 cm),** in *lowland rivers* the trend goes to **discharges bigger ADMF** to maintain **flow velocities and depth**, **some types of rivers** show a **trend to decreasing minimum flows (climate change)** which also needs to be considered adequately – next step is **regionalisation!**
- **ADMF** = **a natural catastrophic event** -> a **dynamic component** to this **minimum base flow** to **maintain the river type specific flow variability is recommended**, contributing to the **maintenance of natural geomorphologic (e.g. sediment quality)** and **ecological processes** linked to **natural flow patterns.**
- **ADMF and hydromorphological cut values implemented in National Water Act for WFD!**

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