Le projet FIThydro **(Fishfriendly innovative technologies for hydropower)**: comment concilier contraintes environnementales et production hydroélectrique

Laurent DAVID

Institut Pprime, CNRS-Université de Poitiers

Pole Eco-hydraulique OFB/IMFT/PPRIME

Avec M. Dewitte, F. Lemkecher, L. Chatellier, D. Calluaud, G. Pineau, S. Jarny, T. Larrieu, D. Courret, S. Tomanova, P. Sagnes

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Quelques éléments clés

26 PARTENAIRES: 13 laboratoires, 13 industriels de 10 pays EU

But du projet:

- Développement de solutions environnementales rentables pour une énergie hydroélectrique durable et respectueuse des poissons en examinant des mesures et des stratégies d'atténuation d'impact
- Développement d'outils d'aide à la décision pour la mise en service et l'exploitation de centrales hydroélectriques en utilisant des technologies existantes et innovantes

BUDGET: 7.2 Mio. €

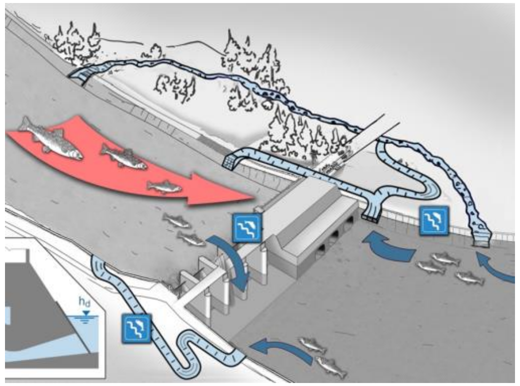
DUREE: Novembre 2016 – Avril 2021

Recherche et Innovation en Europe - SMTDs

Solutions, Methods, Tools et Devices (SMTDs) pour une hydroélectricité respectueuse des poissons

Solutions

- Améliorations structurelles
- Guidage et protection des poissons
- Modélisation numérique du comportement des poissons et attractivité efficace des écoulements



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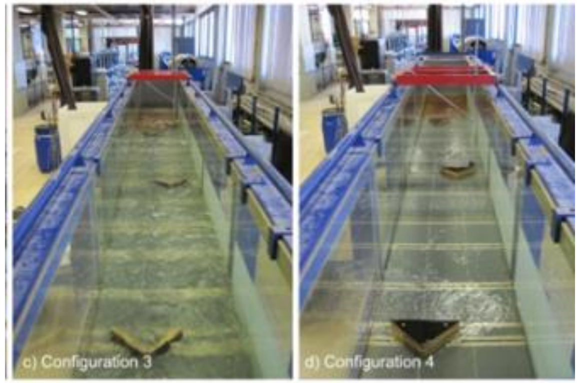
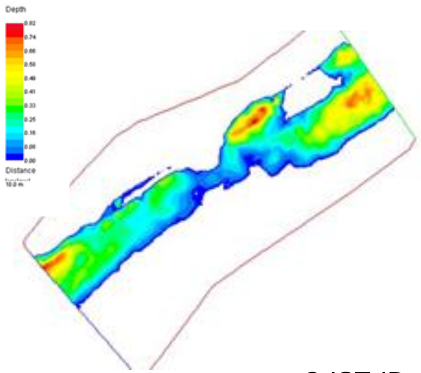
Methods

- Évaluation des écoulements « environnementaux »
- Évaluation de l'impact des éclusées
- Comportement des poissons





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FIThydro

Recherche et Innovation en Europe - SMTDs

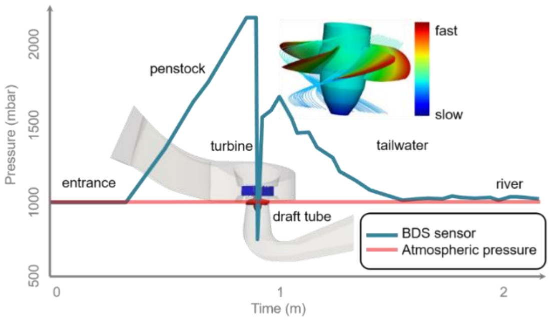
Solutions, Methods, Tools et Devices (SMTDs) pour une hydroélectricité respectueuse des poissons

Tools

- Évaluation de l'impact des éclusées
- Modèle de mortalité des poissons dans les turbines BioPA
- Développer un modèle basé sur un indicateur dans CASiMiR

Devices

- Système de détection Barotroma sensor
- Sonde de ligne latérale
- Suivi par ultrasons 3D sans capteur
- Système de suivi optique 3D



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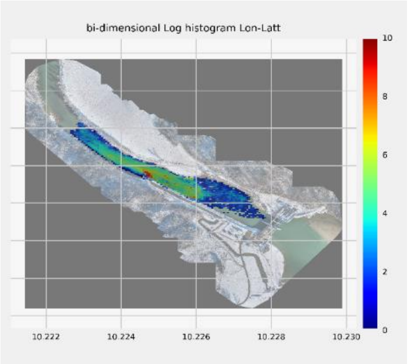

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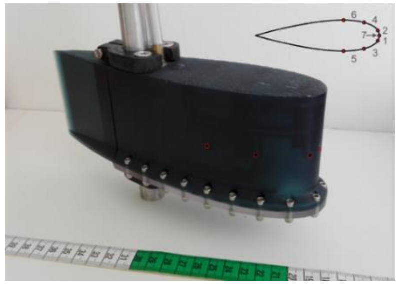

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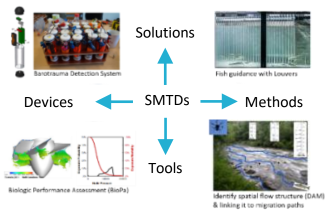
Expected technological impact & key outputs

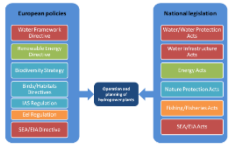
- **Etat de l’art sur les méthodes guidage et protection des poissons des poisons ainsi que le séthodes de mitigationte of the art guidance** on **fish protection facilities, screening**, and **modelling** methods for mitigating environmental impacts of hydropower and minimizing fish losses.
- Planning and implementation procedures to ensure **effective design** and **operation** of hydropower schemes that are **socially** and **environmentally acceptable**.
- Raise the performance of **fish protection** at hydropower plants at the level of **fish populations** by providing the most **cost effective** ensemble of available mitigation measures.
- Relevant stakeholder **participation** in the **planning, implementation** and **use of technological** options for ecologically compatible hydropower production.

FITHYDRO KEY OUTPUTS

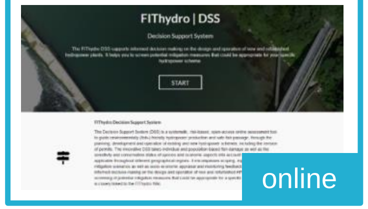
SMTDs



Policy requirements and public acceptance review

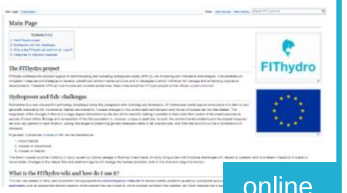


Decision Support System



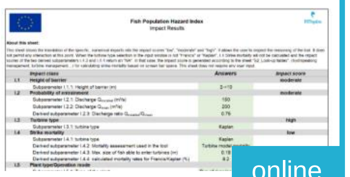
online

FIThydro wiki



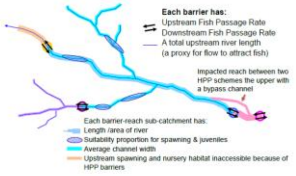
online

Fish Population Hazard Index



online

Cumulative Impact Assessment



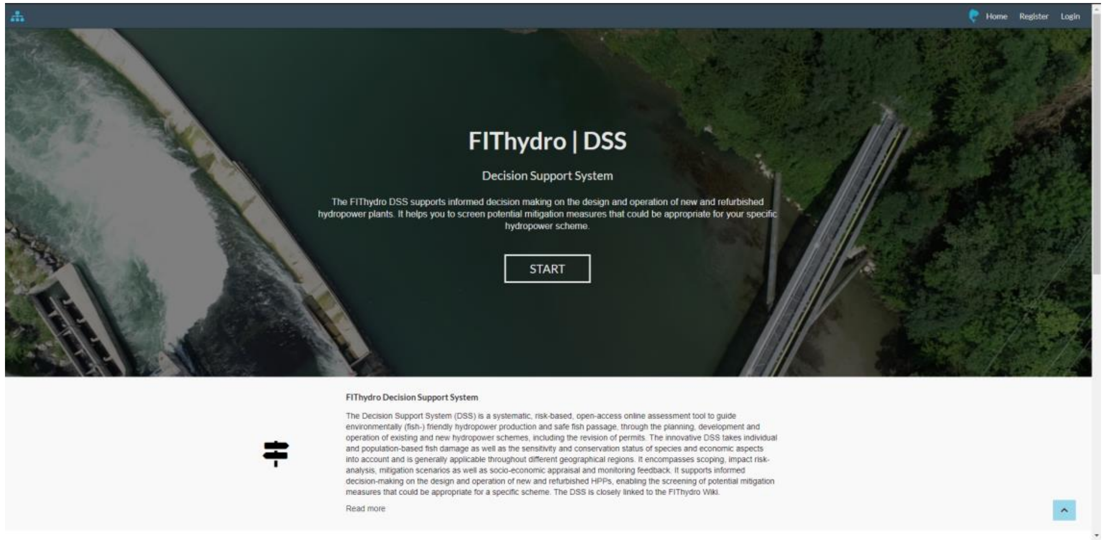
Hydropower Impact Assessment tool

FURTHER INFORMATION: www.fithydro.eu

Fithydro Decision Support System (DSS)

FITHYDRO DSS:

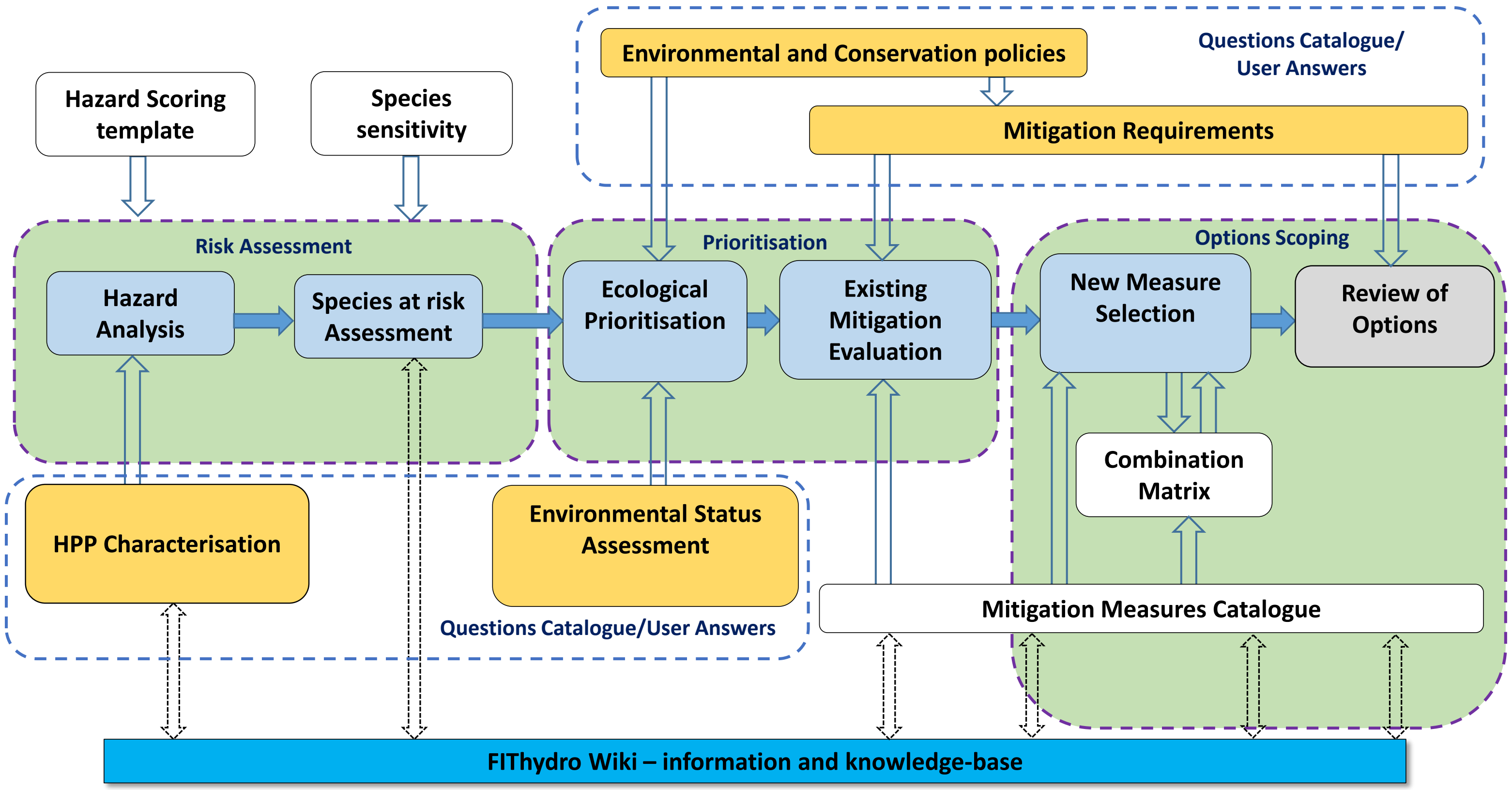
- Support evidence-based decision making regarding mitigation for impacts of hydropower on fish
- High-level scoping tool to complement current planning tools and protocols (IHA, EIA)
- Open access online tool: https://www.dss.fithydro.wb.bgu.tum.de
- For use by regulators, operators, researchers and consultants
- A risk-based approach and decision framework
- Fully integrated with FIThydro Wiki



FIThydro Decision Support System (DSS)

3 Step Decision Framework

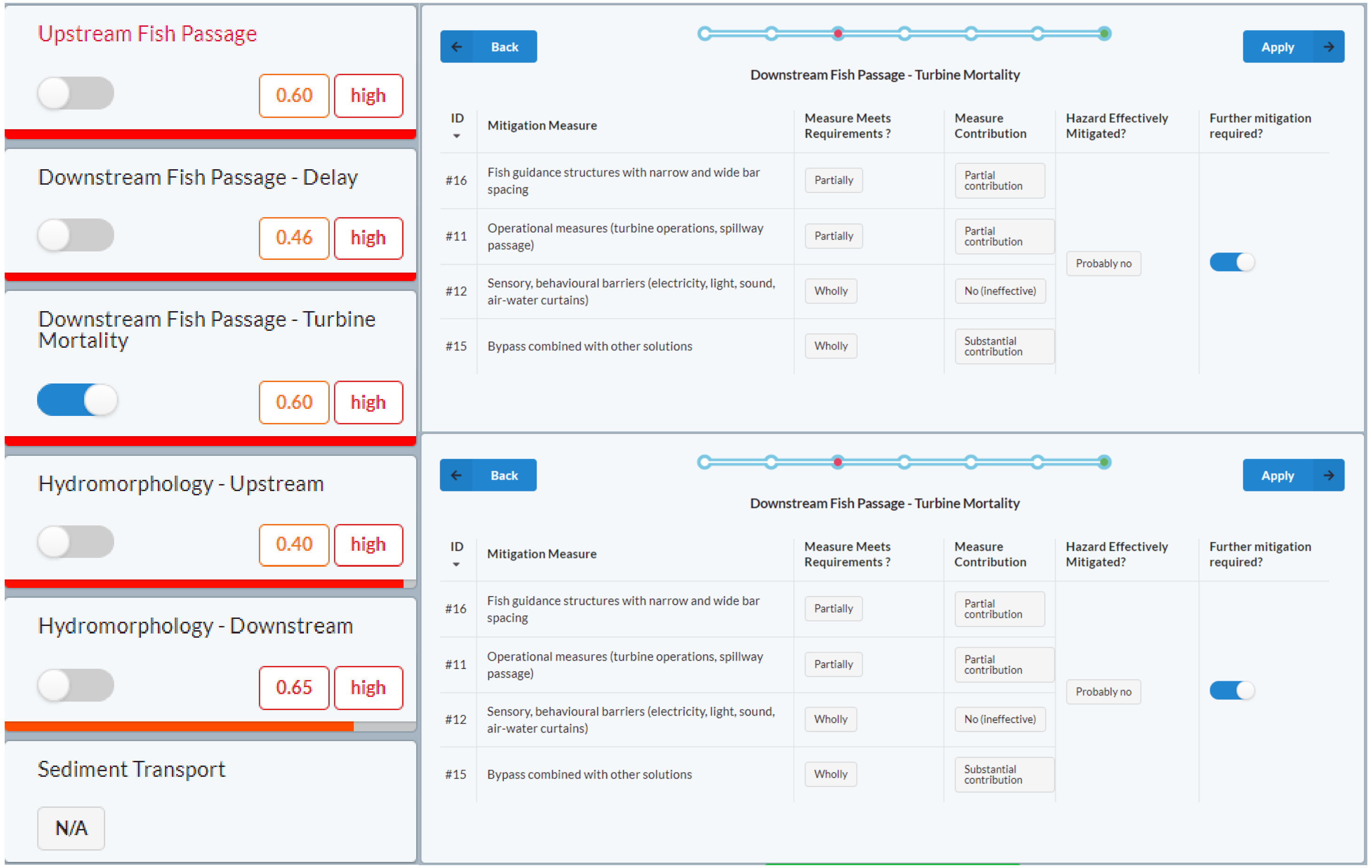
1. Hazard and Risk Assessment
2. Prioritisation and Review of Existing Mitigation
3. Options Scoping of New/Alternative Mitigation Measures



FIThydro Decision Support System (DSS)

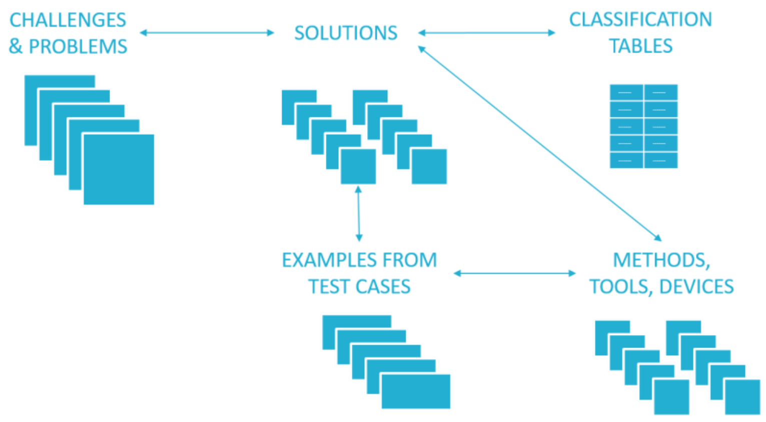
Key Outputs

- Hazard Analysis
- Species Risk Matrix
- Objective-based prioritisation
- Evaluation of mitigation Measures catalogue
- New mitigation plan



Fithydro wiki

- **Open-access online** platform www.fithydro.wiki
- **Systematic presentation** of project outputs and **solutions/mitigation measures** for environmentally friendly hydropower in the categories:
  - Solutions, methods, tools and devices
  - Mitigation measures for: habitat, environmental flow, sediments, downstream and upstream fish migration
  - FIThydro test case applications
  - Policy and public acceptance
- Information provided for each solution includes its characteristics, applicability and suitability, what it mitigates, its TRL and associated costs
- To be used for information purposes and for **rough screening** of appropriate measures, linked to the **Decision Support System**



Relevant MTDs and test cases

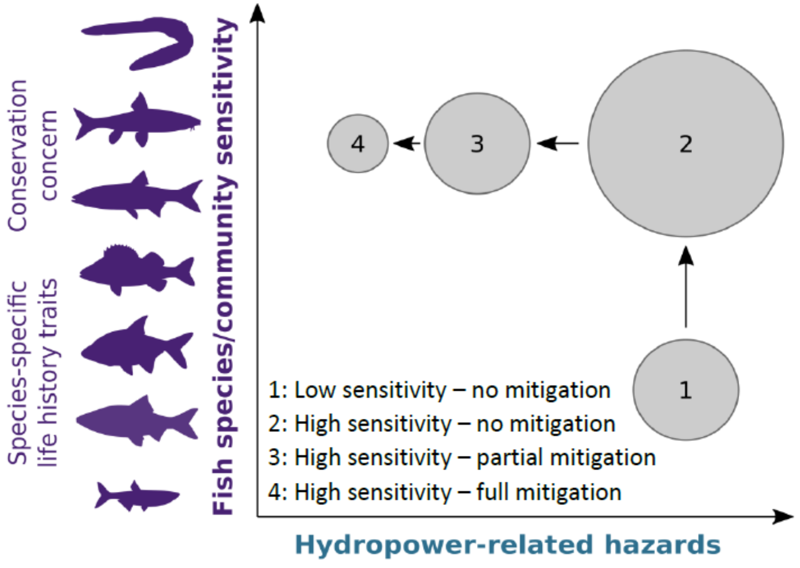
Relevant MTDs
BASEMENT
Bedload monitoring system
CASiMiR
Double Averaging method
HEC-RAS
LiDAR
Shelter measurements
Structure from motion (SfM)

Relevant test cases	Applied in test case?
Guma and Vadocondes test cases	-
Günz test case	Yes

European fish hazard index (EFHI)

Risk Factors Fish Experience during Hydropower Passage

- Hazards are related to
  - flow alterations
  - turbine passage
  - upstream and downstream passage facilities.
- EFHI uses generic knowledge of these risk factors as well as the ambient fish assemblage and computes a **risk score** between 0 to 1.
- The EFHI allows objective **comparison of installations** under consideration of **local/regional biotic conditions** and **stream characteristics**.

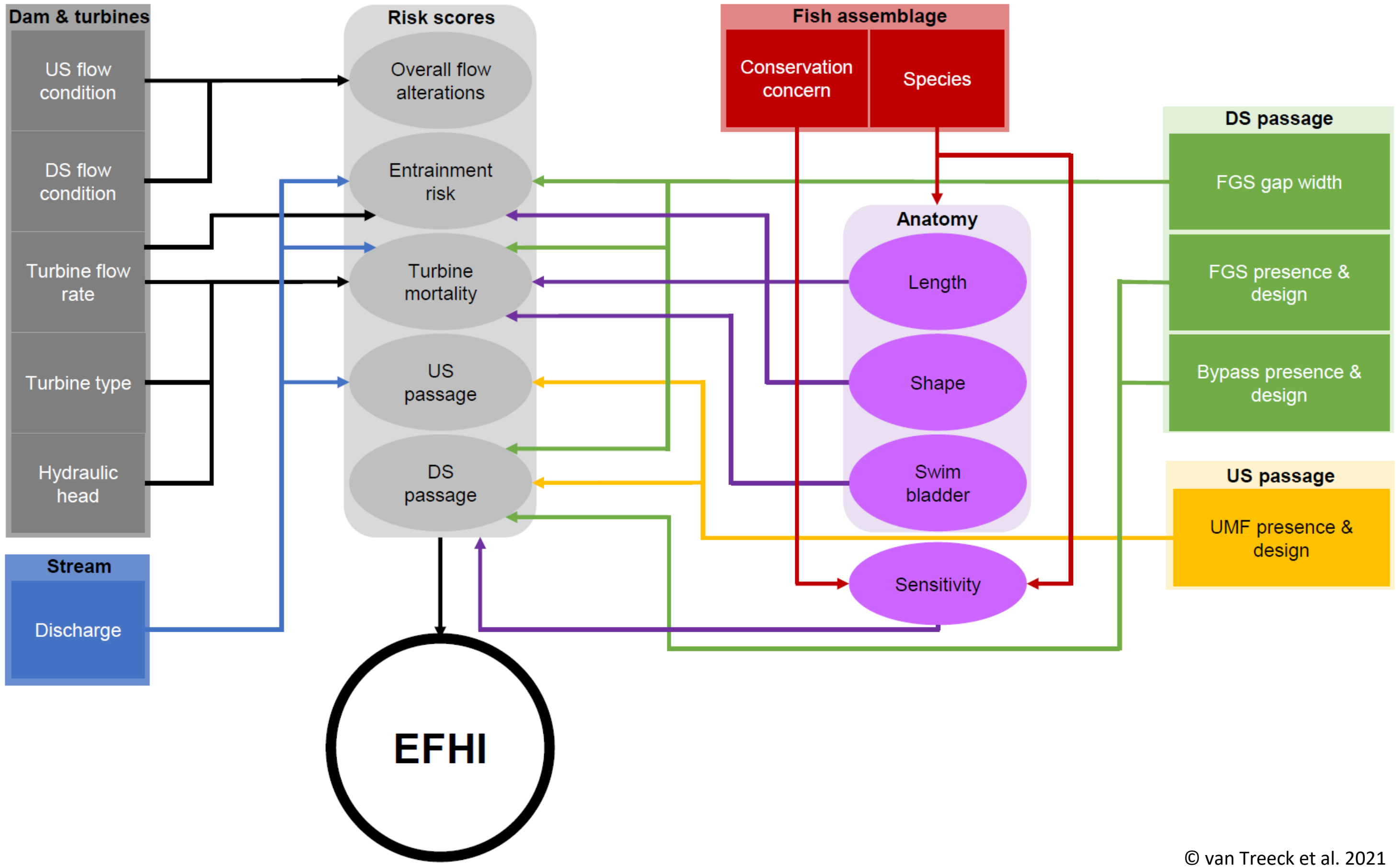


European fish hazard index (EFHI)

Mechanistic Model of EFHI

Categories of data used:

- Plants specifications
- Stream discharge metrics
- Downstream migration & turbine-deflection measures
- Upstream passage facilities & design discharge
- Fish assemblage



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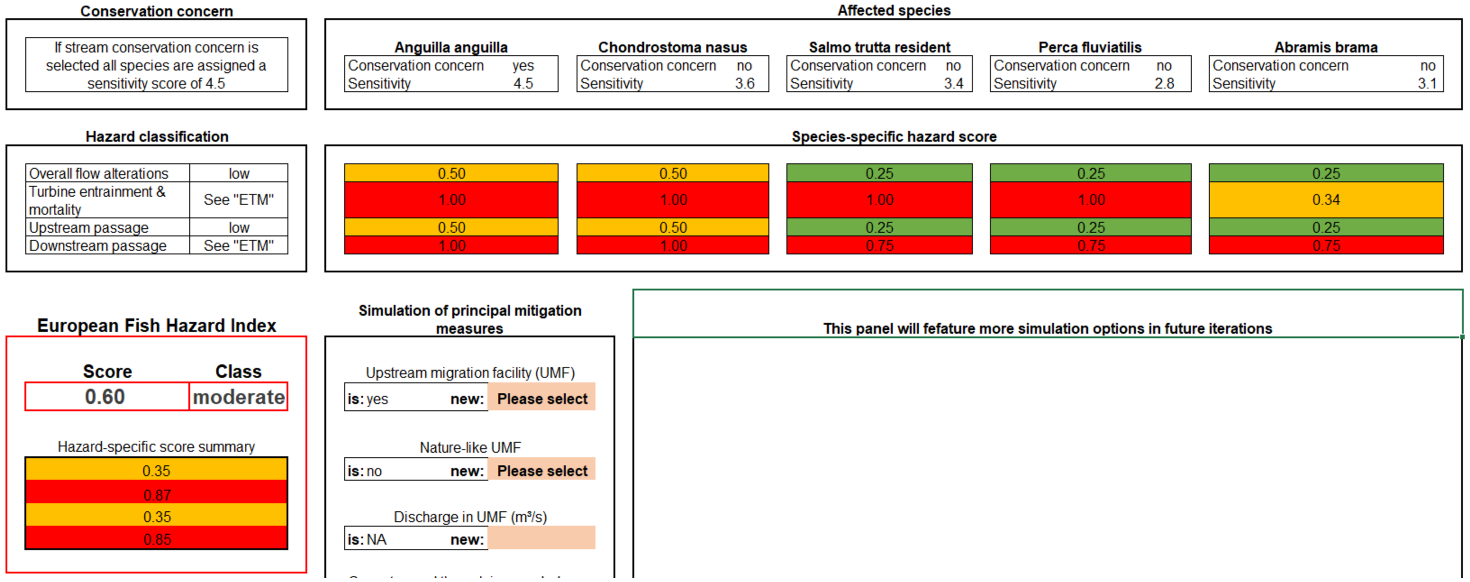
European fish hazard index (EFHI)

APPLICABILITY AND LIMITATIONS

- EFHI serves as a first approach to **identify risk factors** or „risky constellations" of hydropower plants
- When a risk is identified detailed investigations should follow
- EFHI is a **risk assessment tool** and does not replace impact assessment studies



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EU policy framework

EU POLICIES RELEVANT TO PLANNING AND OPERATING HPPS

- FIThydro aims to support the planning of mitigation measures for the **3rd River Basin Management Plans** of the **WFD** (2021-2027) and for achieving biodiversity protection targets especially for fish of the **Habitats Directive**.
- Also aims to support EU policies on renewable energy and climate change adaptation
- Other EU policies relevant planning and operating HPP include the Eel Regulation, the Invasive Alien Species Regulation and the Strategic Environmental and Environmental Impact Assessment Directives (SEA/EIA)

EUROPEAN POLICIES

- Water Framework Directive
- Renewable Energy Directive
- Biodiversity Strategy
- Birds/Habitats Directives
- IAS Regulation
- Eel Regulation
- SEA/EIA Directive

Review of national policy requirements

Policy Review in Eight Countries

- Countries: Norway, Sweden, France, Portugal, Spain, Germany, Switzerland, Austria
- WFD and recently revised national acts as strong drivers for modifying the commissioning and permitting procedures for HPP (inclusion of mitigation measure requirements).
- Mitigation of disrupted upstream fish migration and modified flows usually based on laws. Still widespread lack of policy requirements to mitigate impacts on sediment transport, downstream fish migration and from hydropeaking (ongoing research/pilots to close knowledge gaps).
- Uncertainties in policy framework, e.g. on outcome of permit renewal processes, interpretation of WFD by authorities and courts, no clear specified timeframe for implementing measures in existing HPP

NATIONAL LEGISLATION

- Water / Water Protection Acts
- Water Infrastructure Acts
- Energy Acts
- Nature Protection Acts
- Fishing / Fisheries Acts
- SEA / EIA Acts

the local public acceptance of hydropower

PUBLIC ACCEPTANCE OF HYDROPOWER SURVEY

METHOD

- Application of Q-methodology to reveal subjective views on hydropower of local residents in 4 European case study towns

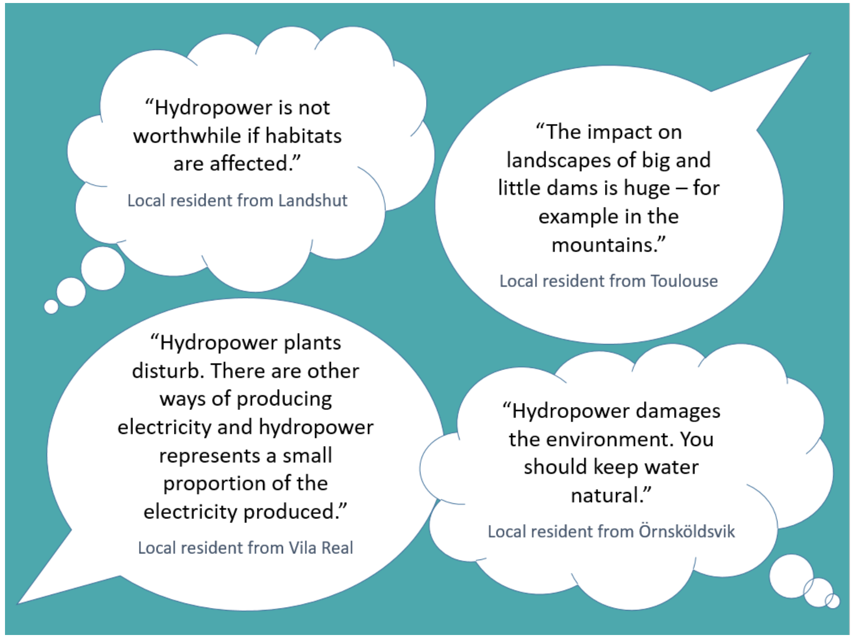
KEY RESULTS

- Overall positive perception of hydropower
- Small number of controversial issues identified, e.g.
  - Fear that private, multinational hydropower companies might neglect the interests of the local population
  - Concern about negative ecological effects of hydropower

the local public acceptance of hydropower

Some Insights Gained on Mitigation Measures

- Application Awareness on mitigation measures is often lacking – but necessary for acceptance!
- Locals are largely in favour of ecological measures, but only if they demonstrate efficacy
- Misconceptions about how fish passes work
  - E.g. “I don’t see fish in the pass, so I assume it does not work”
- **Ways to enhance acceptance of measures:**
  - Awareness campaigns promoting the multiple benefits of ecological measures
  - Establishment of comparable monitoring standards



Quotes from respondents on ecological effects of hydropower facilities

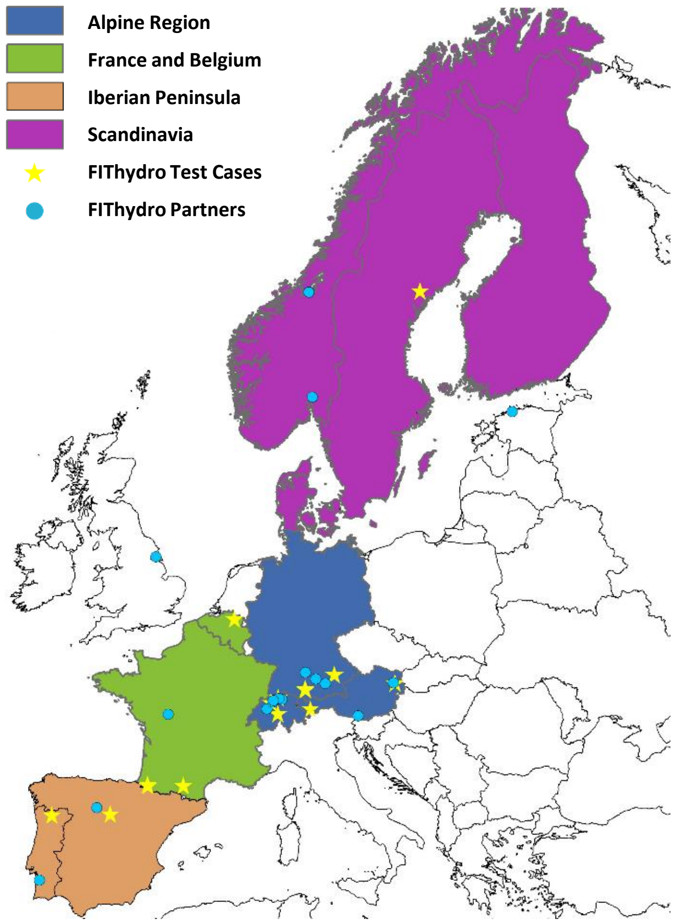
Research and innovation across Europe – Test Cases

CAS TEST:

Les technologies, méthodes, outils et dispositifs sont évalués, améliorés et appliqués sur 16 sites d'essai dans 4 régions européennes.

CHALLENGES RELEVES:

- Montaison
- Dévalaison
- Ecoulement et habitat
- Sédiments



Montaison

Investigation de:

- Chemin utilisé par les poissons
- Attractivité des écoulements
- Entrée des passes à poisson et préférences

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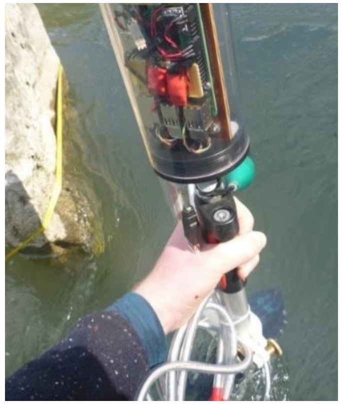

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Dévalaison

Investigation de:

- Chemin utilisé par les poissons
- Efficacité des plans de grille
- Passage dans les turbines

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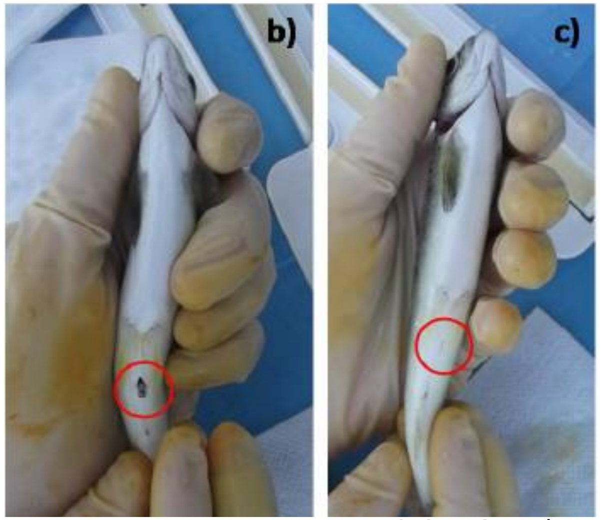

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Ecoulement et habitat

Investigation de:

- Distribution d'habitat et potentiel
- Ecoulement dans les tronçons courcircuités
- Fonctionnement lors des éclusées

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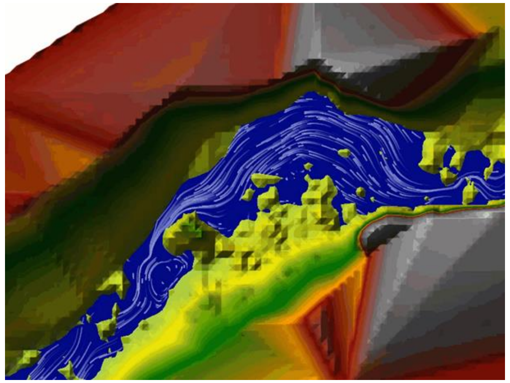

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Sédiments

Investigation de:

- Transport sédimentaire et son management
- Sédiments en lien avec l'habitat

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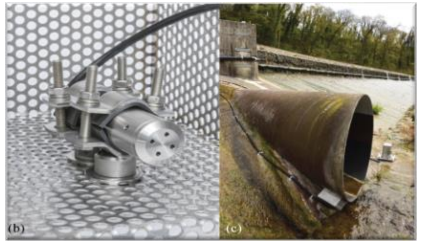

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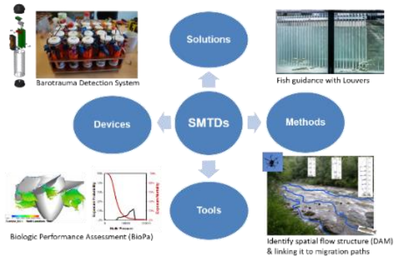
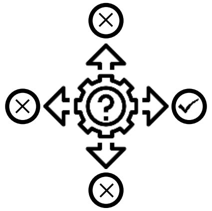
Resultats & produits

SMTDs



Mesures de mitigation

Système d'aide à la décision



FIThydro wiki

Outil d'analyse des impacts cumulés

Indice de danger pour la population de poissons

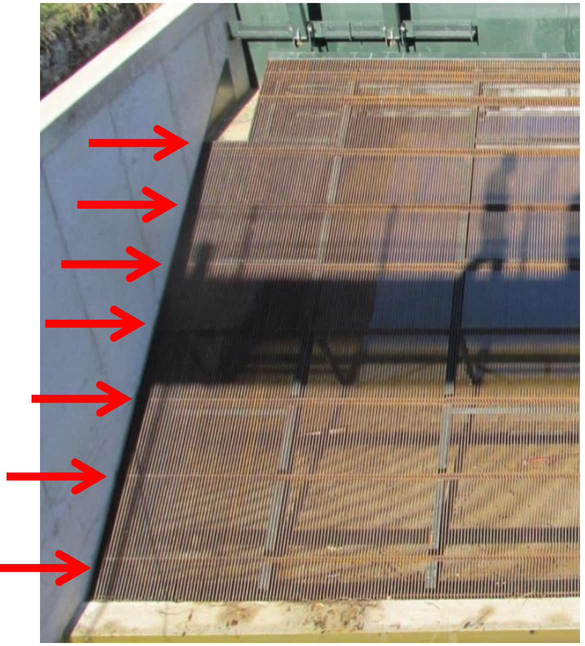
Exigences de la politique et examen de l'acceptation par le public

Outil d'évaluation de l'impact de l'hydroélectricité

PLUS D'INFORMATIONs: www.fithydro.eu

CONTACT: info@fithydro.eu

Quelques résultats sur la dévalaison



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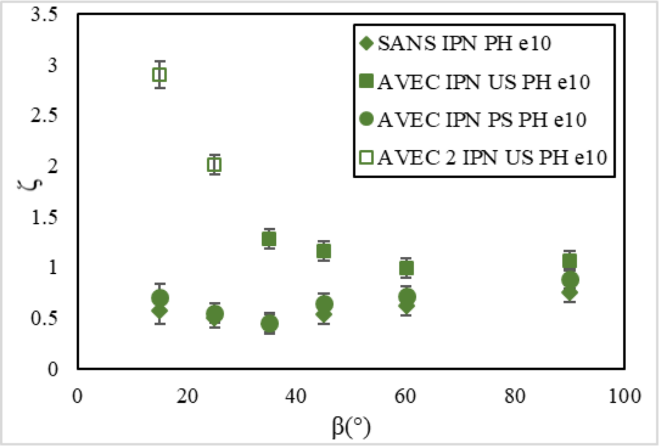

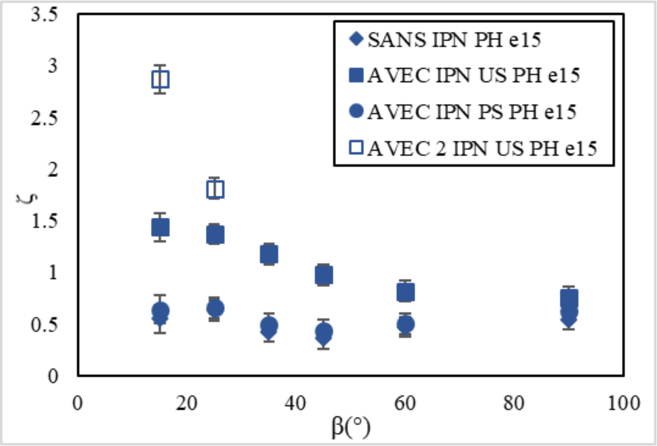

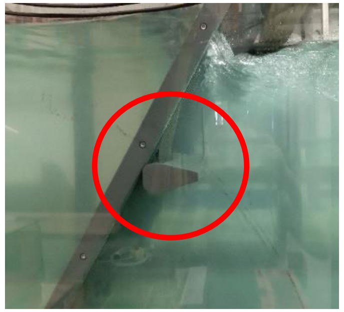

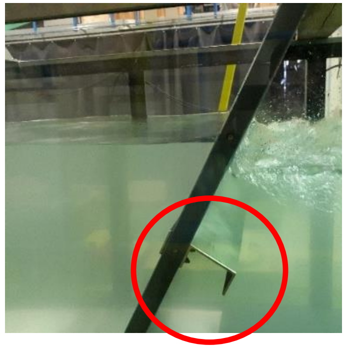

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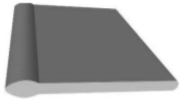
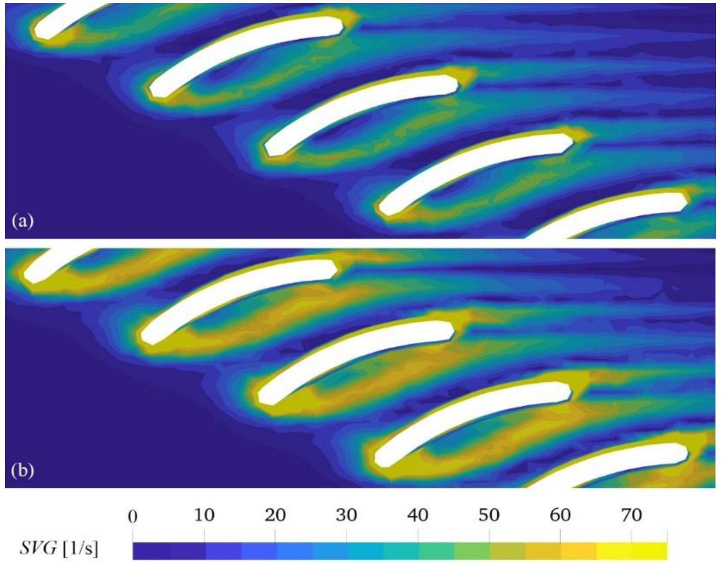
Bar shape	Rectangular	Droplet	Hydrodynamic	Tadpole 10	Plétina	Tadpole 8
						
A	3.85	2.47	2.10	1.79	1.75	1.27

Société ALR

Quelques résultats sur la dévalaison



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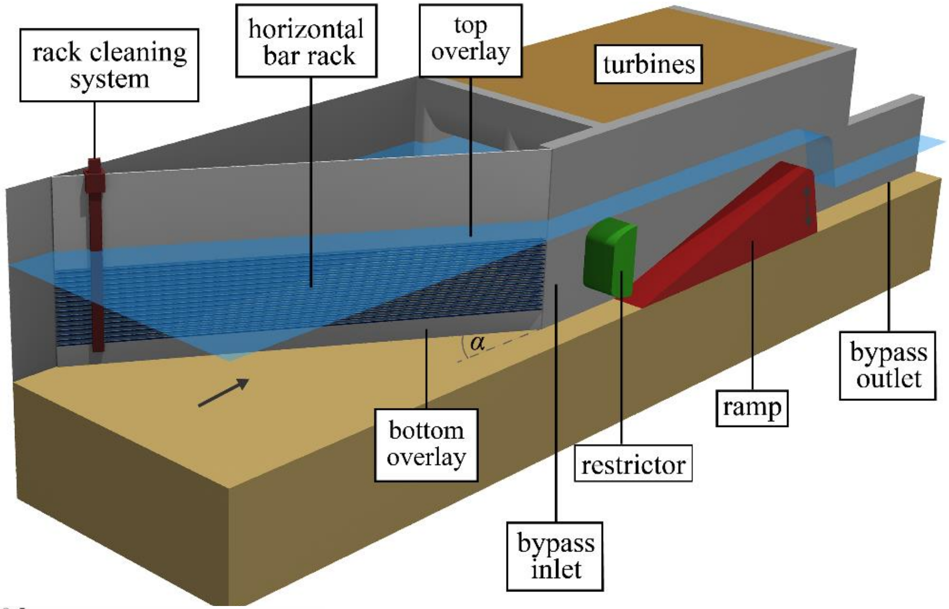

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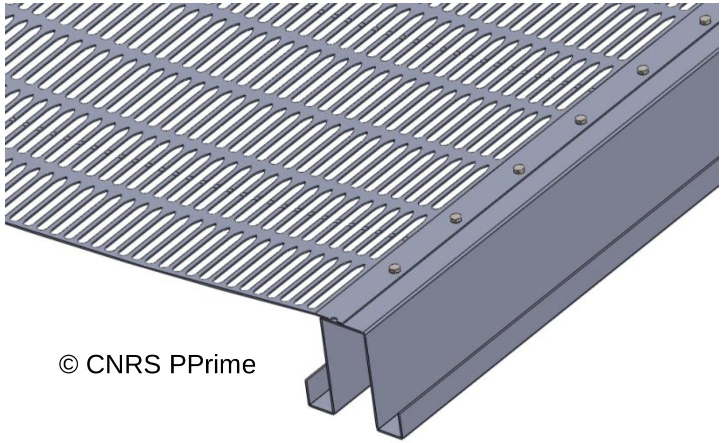

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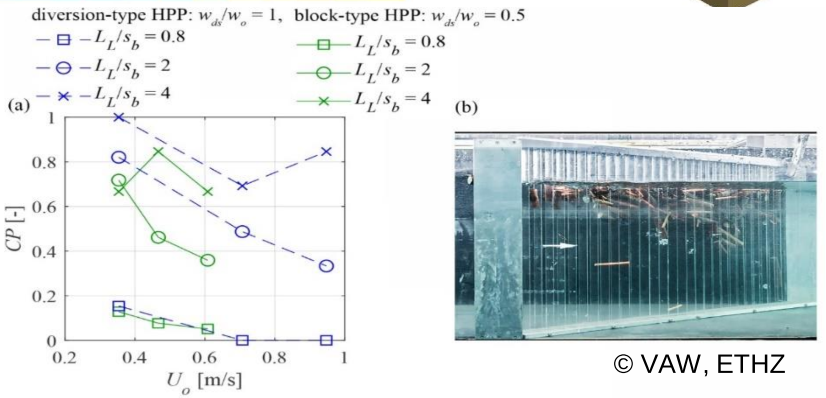

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Quelques résultats sur la dévalaison

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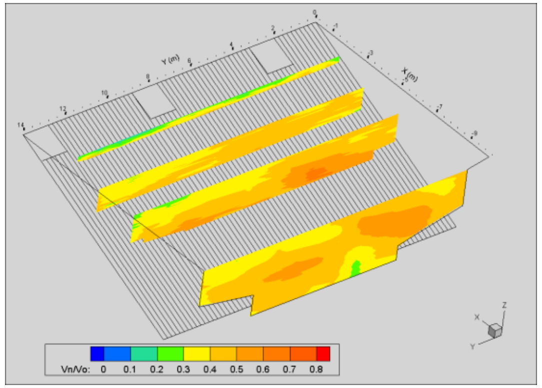

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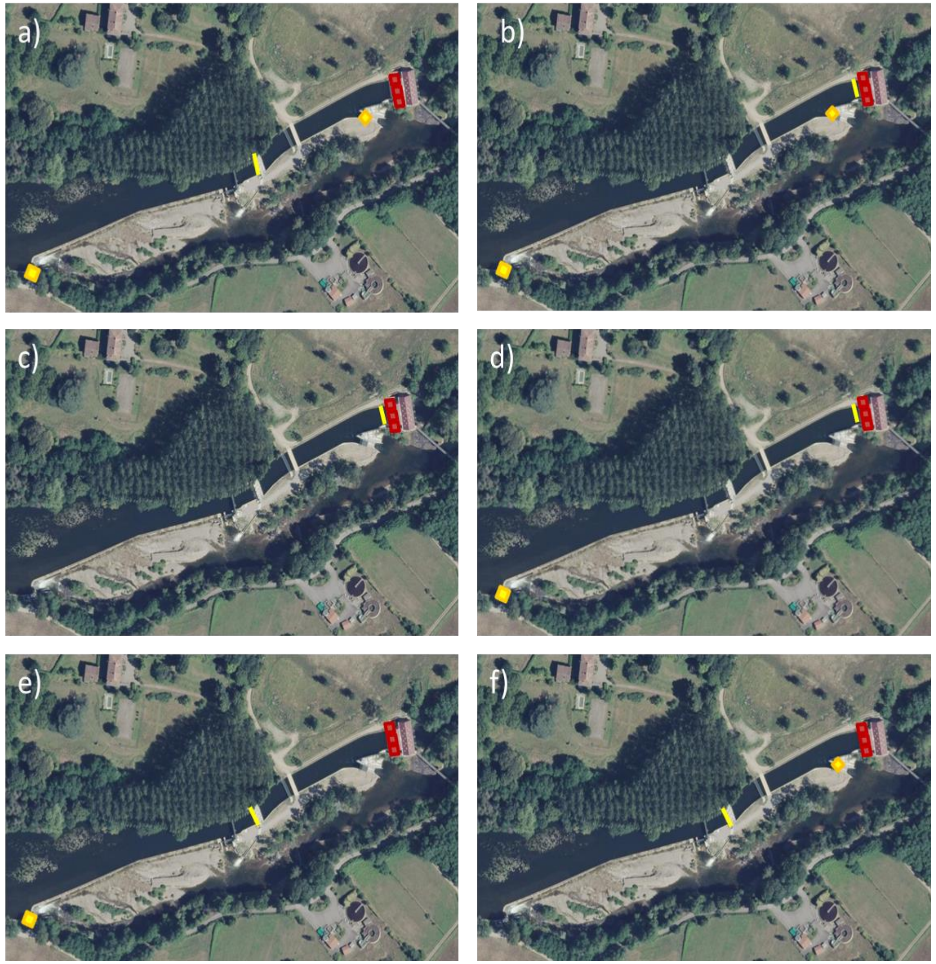
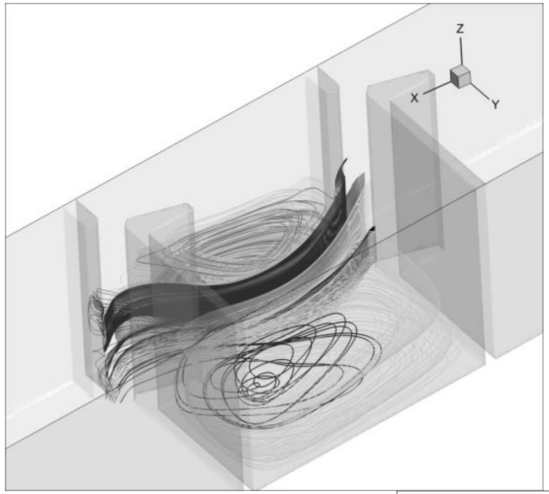
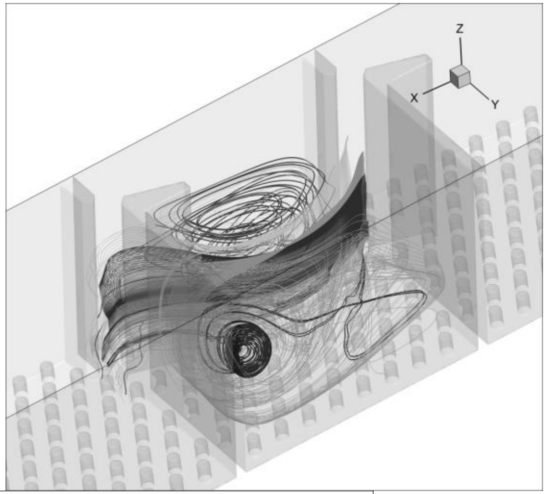
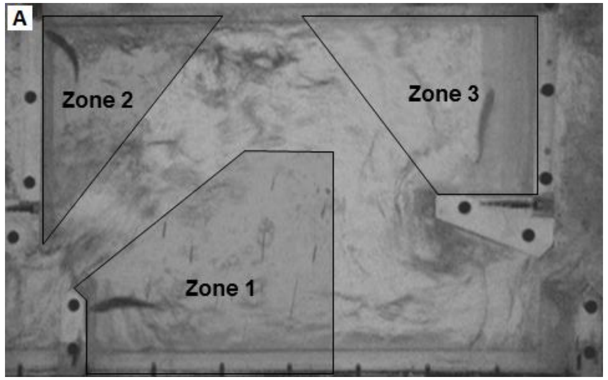
No of Ind.	Length(mm)		%Undetected	%Detected				%efficiency
	Min.	Max.		Bypass	Fishpass	Spillway	Turbines	
Trois-Villes : Atlantic Salmon smolts (note: 30.7% ind. passed through the dump channel)								
300	159	221	7.7*	61.0	0.67	0.6**	7.0**	89.7
Gotein : Atlantic Salmon smolts								
302	150	220	17.2*	80.8	2.0	5.6**	11.6**	82.8
Las Rives : Atlantic Salmon smolts								
150	161	190	8.7	58.7	26.0***		10.0	86.3
Las Rives : Silver Eels								
194	549	930	30.9	35.1	34.0***		0.0	100.0



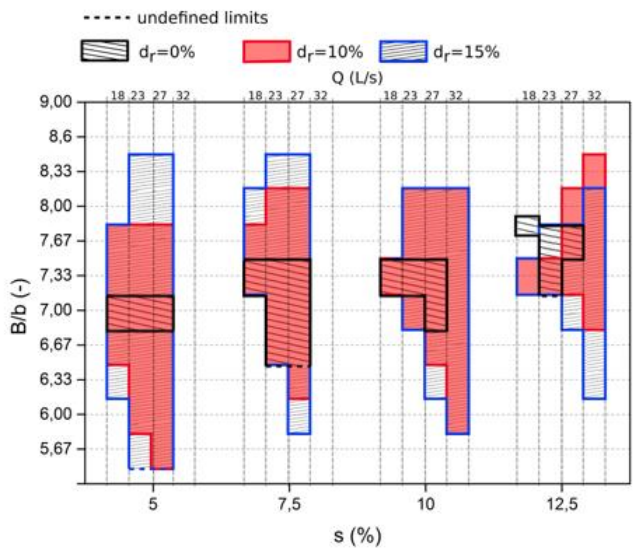
Quelques résultats sur la montaison





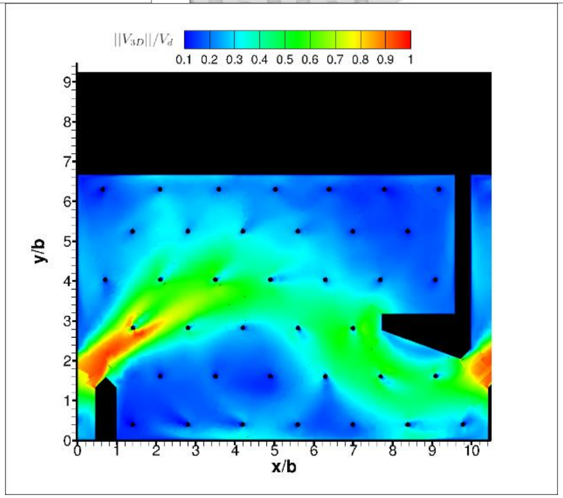


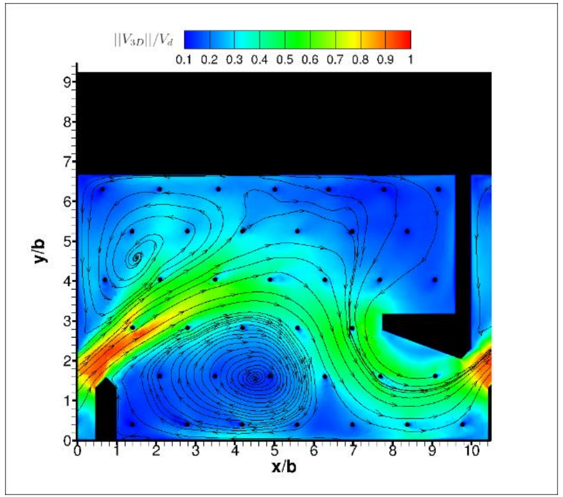
Rugosités de fond



Structures Flexible places au fond

Expé: PIV





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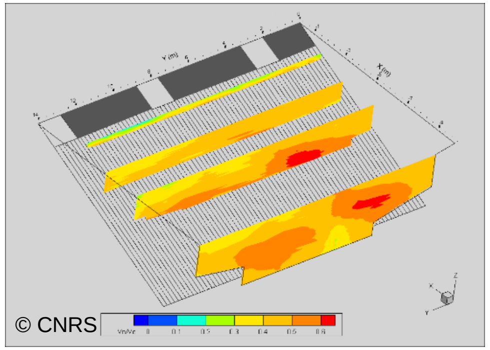
Test case las rives, france

CHALLENGES:

- Efficiency of fish friendly water intake and design of fish friendly water intake for bypass attractiveness
- Cumulative effects on downstream migration delay
- Habitat conditions



MAIN RESULTS:

- Radio telemetry tests for downstream migration: Efficiency 82% for smolts and 100% for eels
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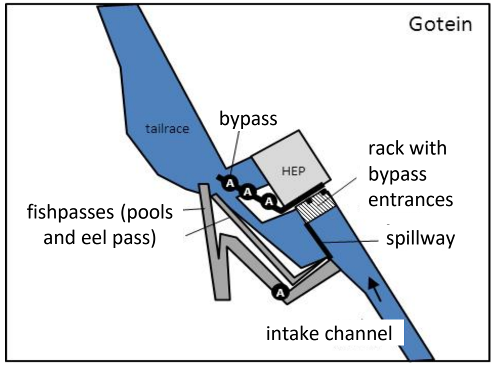
Test case gotein, france

Challenges:

- Efficiency of trash racks for migration
- Design of bypasses (shape, no., bypass channel)
- Attraction and upstream flows



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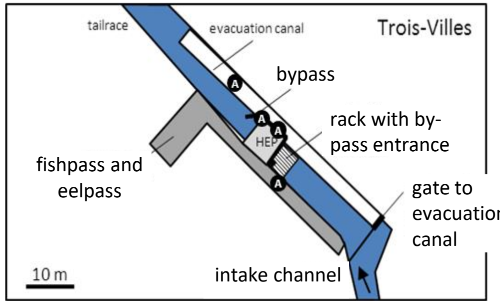

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- Modeling the intake shows the by-pass attraction. This is compared to ADCP measurements

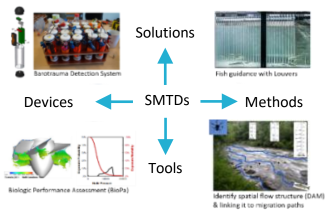
FIThydro

Conclusion

- **Délivrables**
- **Wiki**
- Législation et acceptation du public
- Différents outils
- Des aides à la décision
- Modélisation de scénarii

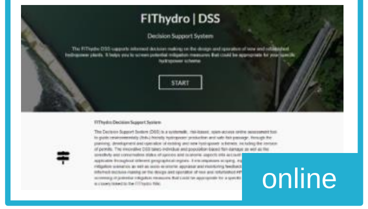
FITHYDRO KEY OUTPUTS

SMTDs



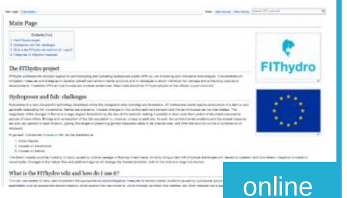
Policy requirements and public acceptance review

Decision Support System



online

FIThydro wiki



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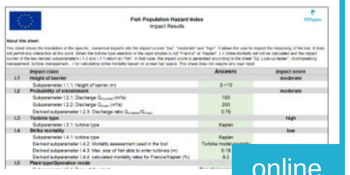
Fish Population Hazard Index



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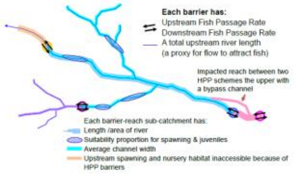
Cumulative Impact Assessment



Hydropower Impact Assessment tool

FURTHER INFORMATION: www.fithydro.eu

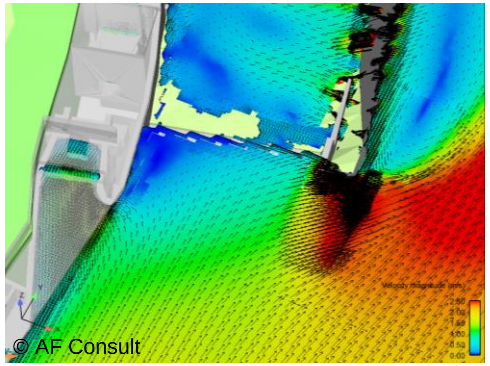
Merci

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727830

Test case Schiffmühle, switzerland

CHALLENGES:

- Downstream migration
- Upstream migration
- Attraction flow; downstream fish habitat
- Sediment management



MAIN RESULTS:

- Nature-like and vertical slot fishways function well with high fish passage efficiency
- Inefficient attraction flow to the bypass for downstream migration
- Downstream bypass system needs optimization
- Vortex tube functions well for sediment transport during floods

Test case Bannwil, switzerland

CHALLENGES:

- Downstream migration
- Turbine migration
- Combination of measures (spill and structural measures)

MAIN RESULTS:

- No fish injury is expected for passage over the spillway.
  Effective fish impact velocity < critical terminal velocity
- Predation risk are expected due to gas-bubble disease from baffle block strikes
- Stilling basin geometry needs optimisation
- Unfavourable hydraulic conditions at potential location of an angled fish guidance structure
- High fish friendliness scores for the turbines of the power plant

Test case altheim, germany

CHALLENGES:

- Habitat availability and usage in fishway
- Maintenance efforts and costs

MAIN RESULTS:

- The installed habitat structures provide a significant ecological benefit, providing specific habitats for different species
- High velocity and cool water temperature in fish pass enable a sustainable grayling population (threatened species) as well as suitable habitat for ground oriented fish species
- Maintenance effort mainly increases with length of fish pass not with implementation of habitat structures

Test case Altusried, germany

CHALLENGES:

- Entrance of fishway for upstream migration
- Attraction flow

MAIN RESULTS:

- High no. of fish species and population size indicates good use of nature-like fishway (formerly poor fish community status)
- Especially barbell, Danube salmon, grayling, cub and brown trout found
- CASiMiR-Migration model shows a low/decreasing attraction flow with higher flow velocities. As fish do use the fishway regardless, additional parameters to flow magnitude and direction need to be considered.

Test case river günz, germany

CHALLENGES:

- No solution for downstream migration
- Spawning grounds and juvenile habitats

MAIN RESULTS:

- Construction of habitat structures for spawning and juvenile fish in nature-like fishway: Successful spawning on fresh gravel (on 50% spawn of nase found)
- High number of target fish species found in and migrating through fishways
- Nase preferred new, clean gravel, resulting in an expected very good functioning of new spawning grounds for about two years.

Test case Ham, belgium


© De Vlaamse Waterweg

Challenges:

- Downstream migration path
- Physical impact of the turbines on passing fish
- Attraction flow of bypass channel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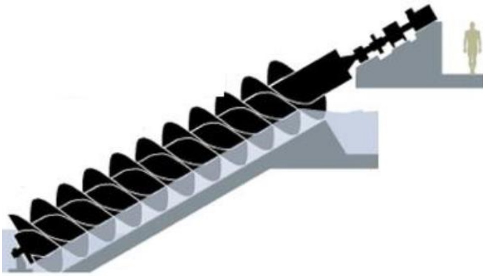

Main Results:

- No salmon smolts and 9 % of eel passed downstream via the by-pass channel
- During screw passage, 17% of eels have a chance to die or get heavily injured
- Contusion is the main type of damage, pressure-related injuries seems unlikely
- No difference in impacts on fish at 3, 4 or 5 m3/s turbined water

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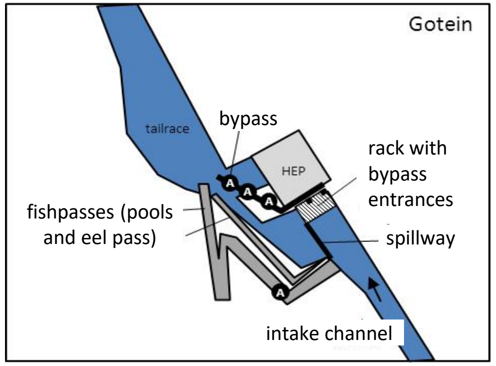

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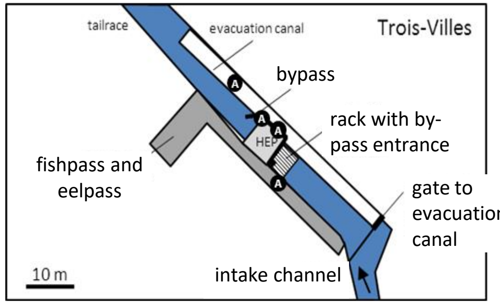

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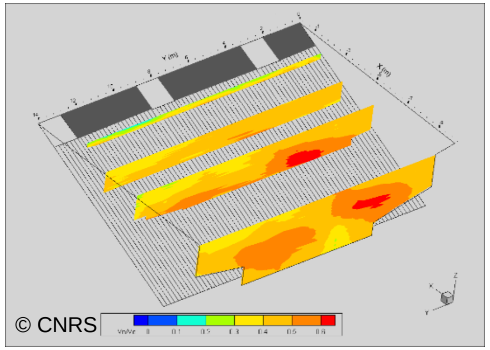

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Test case Bragado, portugal

Challenges:

- Hydropeaking effect for the Iberian cyprinids
- Habitat preferences

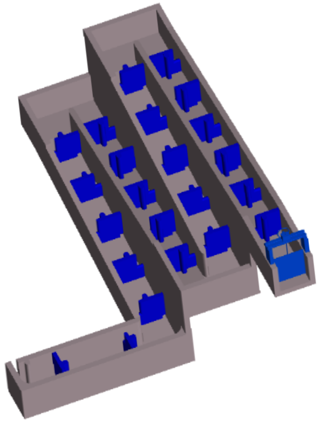
Main Results:

- Fish community is dominated by small size cyprinids
- Likely due to hydropeaking, a higher density of fish were found upstream the HPP tailrace. Only nase was found immediately downstream the water release in the most disturbed area
- Installed lateral refuge (~50 m downstream of the tailrace) is used ~10 min after turbine operation starts. Larger adults tend to appear after the turbine discharge ≥ 1 m^3/s
- Hydropeaking assessment resulted in a moderate hydropeaking impact

Test case Guma, spain

CHALLENGES:

- Downstream migration (turbine passage survival)
- Upstream migration and fishway function
- Spawning areas
- Attraction and e-flows



MAIN RESULTS:

- 2D and 3D models of river reach and fishway
- 61% of detected fish ascended the fishway
- Potential spawning areas for native cyprinids is <2% of the total river section area studied
- For downstream migration, 64% of fish that found the fishway descended it

Test case vadocondes, spain

CHALLENGES:

- Downstream migration (turbine passage survival)
- Upstream migration and fishway functions
- Spawning areas

MAIN RESULTS:

- Nature-like 31 % of fish located the fishway and 70% ascended it
- Potential spawning areas for native cyprinids is <2% of the total river section area studied
- Ascend time indicates no significant migration delay caused by the structures

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Test case AnundsjØ, sweden

Challenges:

- Downstream migration pathway
- Smolt behaviour in intake reservoir
- Attraction to fishway
- Habitat/sediments in residual flow

Main Results:

- Failure of downstream migration of smolt. Passage success: 1 out of 40 smolts at dam and 10 out of 20 smolt at bypassed reach
- Applied innovative methods: Structure for Motion (SfM), Double-averaging method (DAM)
- Water velocities too low to allow migration into bypassed reach without additional release of water
- Cost analysis shows release of e-flow for 2h/night more efficient than 2x 1h release/week.

Test case Freudenau, Austria

© VERBUND

CHALLENGES:

- Fish pass entrance
- Potential other reasons for attraction other than flow

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MAIN RESULTS:

- Fish tracking data from the 2D telemetry study with 35 nase was compared with Flow3D model considering hydro-thermo-chemical-mechanical processes.
- While there is a slight temperature difference between the Danube and the fish pass (+/- 0.6°C), the comparison to the fish tracks does not indicate a clear correlation.

Test case GKI, Austria

CHALLENGES:

- Impacts of current hydropeaking
- Hydropeaking mitigation
- Flow changes in river with different habitats
- Habitat for reproduction and juveniles

MAIN RESULTS:

- Characterization of key hydro-morphological components for hydropeaking mitigation
- Operational mitigation measures for grayling’s larval-window regarding hydropeaking impacts
- Enhancement of spawning habitats and habitat suitability of larvae life-stages
- Improved assessment of hydropeaking impacts and evaluation of mitigation measures