

Fish-friendly Innovative Technologies for Hydropower

FIThydro



SMTDs

Identify quantified flow structures (QAMF) & linking it to migration paths

Policy requirements and public acceptance review

Decision Support System

online

FIThydro wiki

online

Fish Population Hazard Index

online

Cumulative Impact Assessment

Hydropeaking Impact Assessment tool

Vulnerability	Hydropeaking effects			
	Very large 21-32	Large 15-20	Moderate 10-14	Small 6-9
High 16-21	Red	Red	Yellow	Green
Moderate 10-15	Red	Yellow	Green	Green
Low 4-9	Yellow	Green	Green	Green

ETIP Hydropower Webinar
26th Februray 2025

Atle Harby, SINTEF Energy Research

Peter Rutschmann and Lea Berg, Technische Universität München



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KEY FACTS

26 PARTNERS: 13 from research, 13 industry from 10 EU countries

PROJECT AIM:

- * Development of cost-efficient environmental solutions for sustainable and fish-friendly hydropower by investigating mitigation measures and strategies
- * Development of decision support tools for commissioning and operating hydropower plants by use of existing and innovative technologies

15 TEST CASES: Germany, Austria, Switzerland, France, Spain, Portugal, Belgium and Sweden

BUDGET: 7.2 Mio. €

DURATION: November 2018 – April 2021

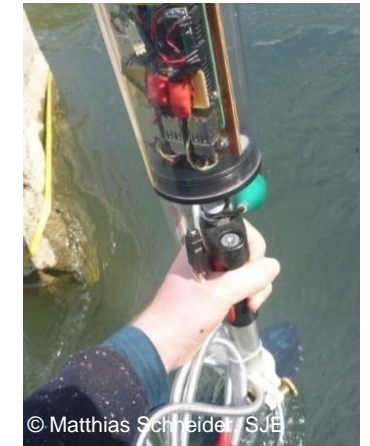


UPSTREAM MIGRATION



INVESTIGATION OF:

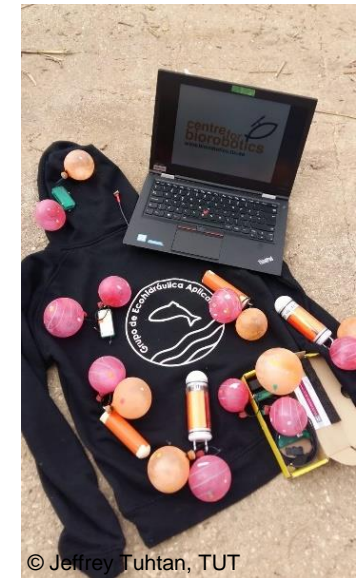
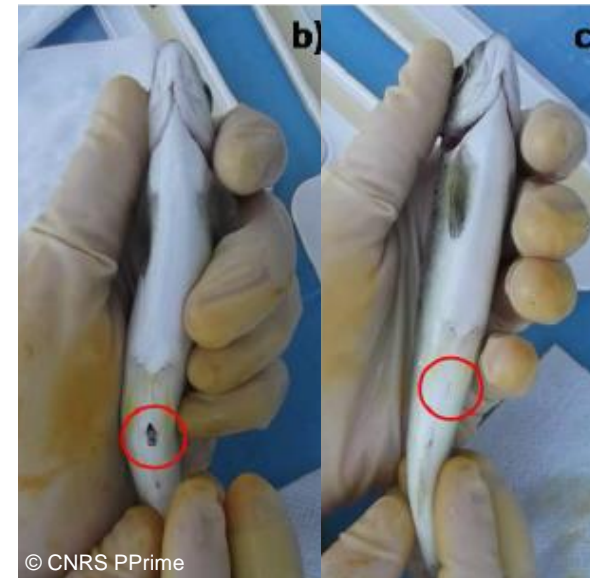
- * Fish swimming path and attraction flow
- * Fishway entrance and preferences
- * Fishway function



DOWNSTREAM MIGRATION

 INVESTIGATION OF:

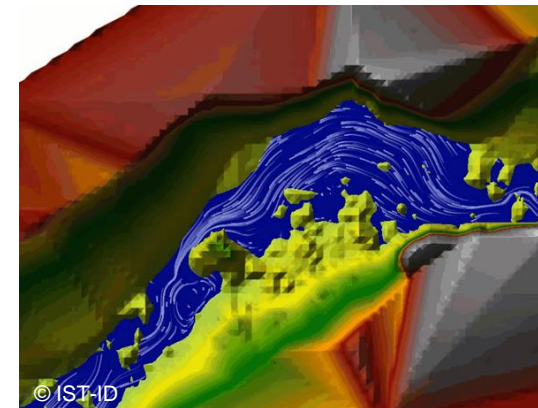
- * Fish swimming path
- * Fish guidance efficiency of bar racks
- * Attraction of by-pass
- * Turbine passage



FLOW & HABITAT


INVESTIGATION OF:

- * Habitat distribution and availability
- * Environmental flow in bypass reach
- * Hydropeaking



SEDIMENTS


INVESTIGATION OF:

- * Sediment transport and management
- * Sediments and habitat availability



RESEARCH & INNOVATION ACROSS EUROPE - SOLUTIONS, METHODS, TOOLS AND DEVICES - SMTDS

SOLUTIONS

- * Structural improvements
- * Fish guidance and protection
- * Efficient fish migration solutions

TOOLS

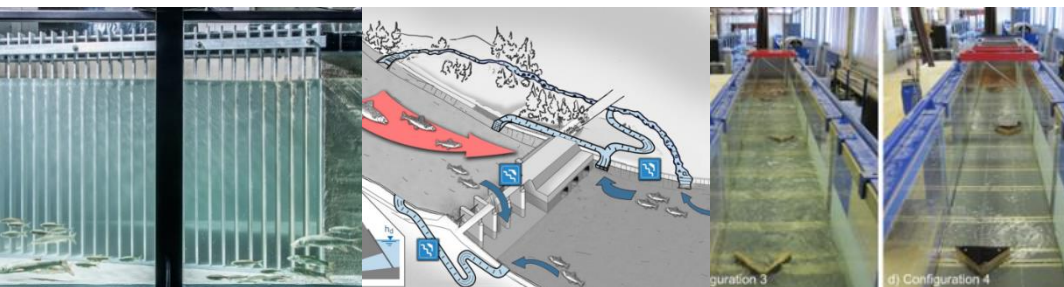
- * Hydropeaking impact assessment
- * Turbine fish mortality model BioPA
- * An agent-based fish swimming model in CASiMiR

METHODS

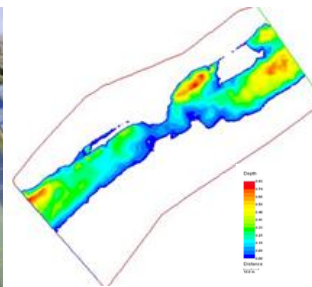
- * E-flow assessment
- * Sediment management
- * Cumulative impact assessment

DEVICES

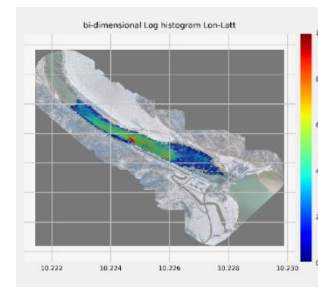
- * Barotrauma Detection System
- * Lateral Line Probe
- * System for 3D optical tracking



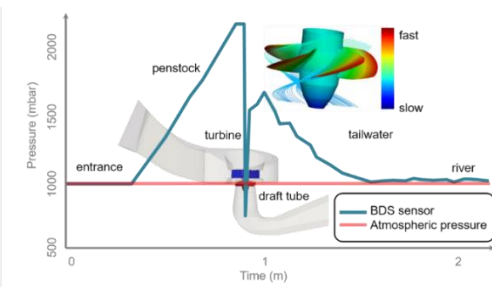
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© SJE GmbH



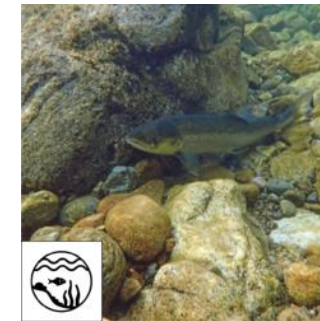
© TalTech, Centre for biorobotics



FITHYDRO WIKI

- * **Open-access online** platform www.fithydro.wiki
- * **Systematic presentation** of project outputs containing **challenges** and **solutions** to obtain environmentally friendly hydropower
- * **Description** of typical challenges for fish in hydropower rivers
- * Solutions for **mitigating challenges** including its characteristics, applicability and suitability, its TRL and associated costs
- * Methods, tools and devices to help **planning, implementing, maintaining and monitoring** the mitigation measures are presented
- * All FIThydro Test Cases are presented with specific information on challenges and **solutions, methods, tools and devices** to mitigate negative impacts on fish

Main challenges:



Habitat



Environmental flows



Sediments



Downstream fish migration

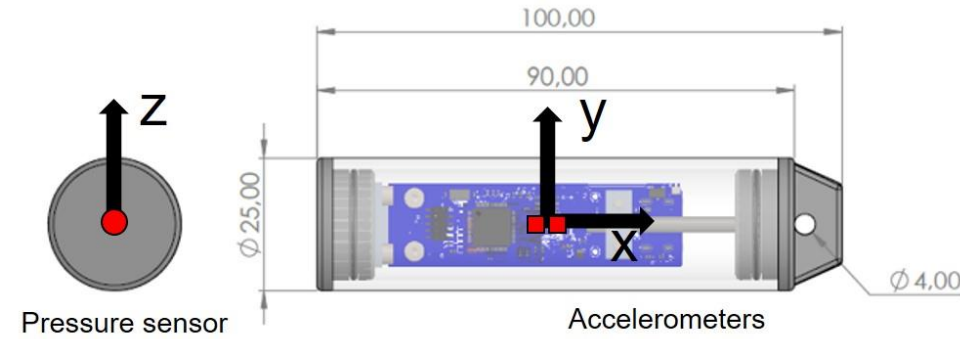


Upstream fish migration

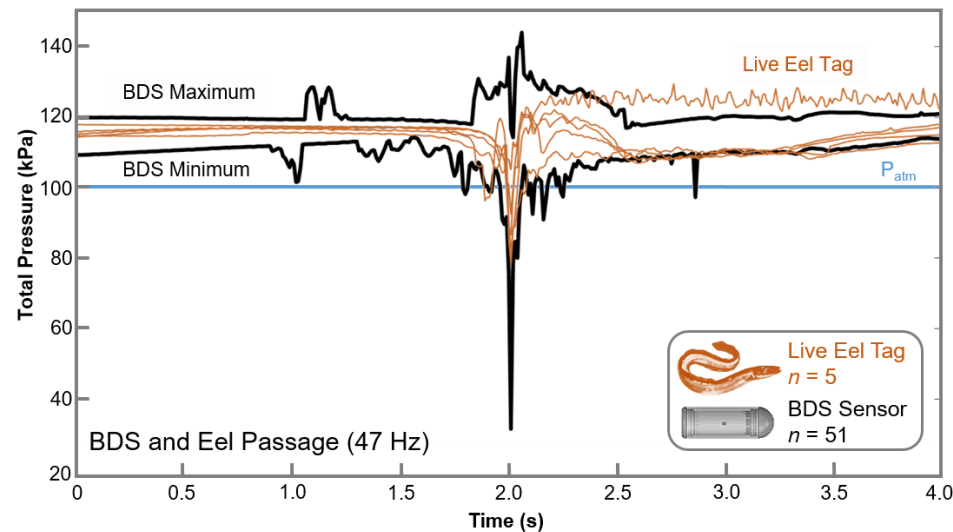
BAROTRAUMA DETECTION SYSTEM

BAROTRAUMA DETECTION SYSTEM (BDS)

- * Rugged underwater sensor for hydropower turbine passage
- * Measures pressure, acceleration, rate of rotation and magnetic field
- * Only existing technology capable of measuring pressure gradients using multi-pressure sensing technology



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INNOVATIVE FISH PROTECTION AND GUIDANCE STRUCTURES

CURVED-BAR RACK – BYPASS SYSTEM (CBR-BS)

- * CBR-BS: mechanical behavioral fish guidance structure
- * Technical solution for downstream fish passage at HPPs
- * Innovative curved-bars improving the hydraulic performance:
 - * Flow straightening effect → symmetric turbine admission
 - * 4.2 times lower head losses compared to straight bar shapes
 - * New head loss factors
- * High fish guidance efficiencies for Spirlin, Barbel, Salmon & Nase

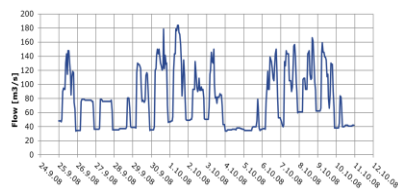


Fish: nase (TL:7.5 cm)

© VAW, ETHZ

HYDROPEAKING IMPACT ASSESSMENT

INPUT DATA



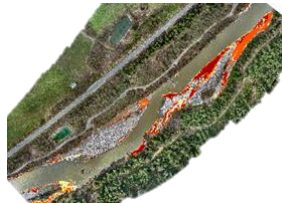
Flow records



COSH Tool



Field measurements



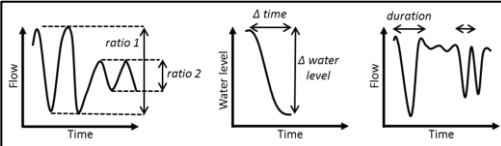
CASIMIR habitat model




Fish population data




Fish population vulnerability



Rate of change, ratio, frequency & timing of water level and flow



Change in habitats



OUTPUT: COMBINED ASSESSMENT

➤ The Hydropeaking Tool classifies the impact and gives direction for mitigation

		Hydropeaking effects			
		Very large 21-32	Large 15-20	Moderate 10-14	Small 4-9
Vulnerability	High 16-21				
	Moderate 10-15				
	Low 4-9				

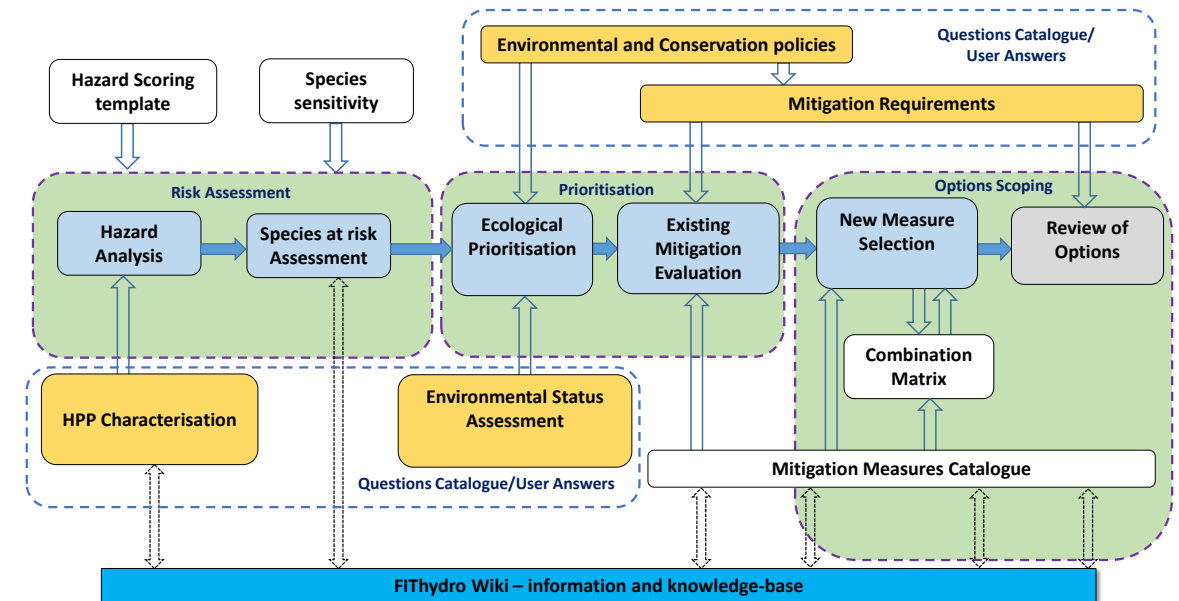
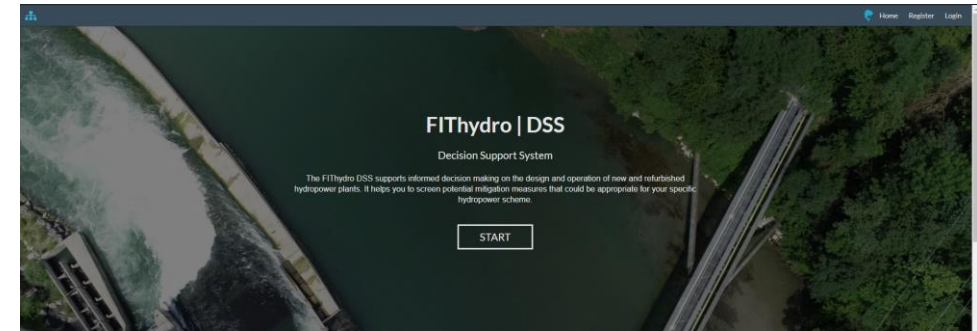
TARGET SPECIES

- * Salmon
- * Iberian cyprinids
- * Grayling

FITHYDRO DECISION SUPPORT SYSTEM (DSS)

FITHYDRO DSS:

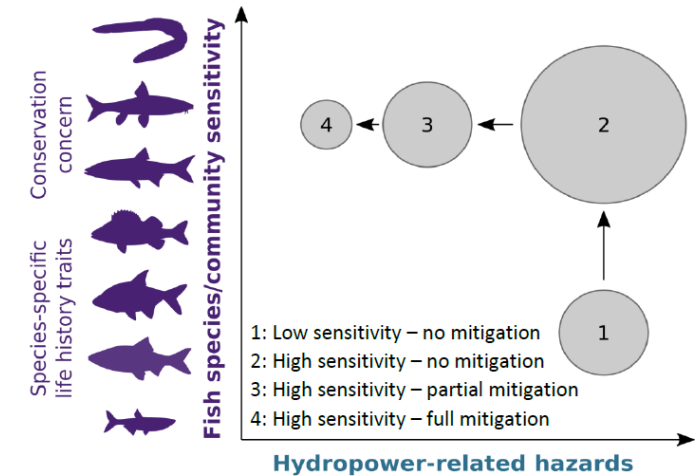
- * Support evidence-based decision-making regarding mitigation for impacts of hydropower on fish
- * High-level scoping tool to complement current planning tools and protocols (IHA, EIA)
- * Open access online tool:
<https://www.dss.fithydro.wb.bgu.tum.de>
- * For use by regulators, operators, researchers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



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.
- * EFHI serves as a first approach to identify risk factors or “risky constellations“ of hydropower plants
- * Input data:
 - * Power plant specifications
 - * Stream discharge metrics
 - * Downstream migration & turbine-deflection measures
 - * Upstream passage facilities & design discharge
 - * Fish assemblage



Conservation concern		Affected species					
If stream conservation concern is selected all species are assigned a sensitivity score of 4.5		Anguilla anguilla	Chondrostoma nasus	Salmo trutta resident	Perca fluviatilis	Abramis brama	
Conservation concern	yes	Conservation concern	no	Conservation concern	no	Conservation concern	no
Sensitivity	4.5	Sensitivity	3.6	Sensitivity	3.4	Sensitivity	3.1

Hazard classification		Species-specific hazard score				
Overall flow alterations	low	0.50	0.50	0.25	0.25	0.25
Turbine entrainment & mortality	See "ETM"	1.00	1.00	1.00	1.00	0.34
Upstream passage	low	0.50	0.50	0.25	0.25	0.25
Downstream passage	See "ETM"	1.00	1.00	0.75	0.75	0.75

European Fish Hazard Index	
Score	Class
0.60	moderate

Simulation of principal mitigation measures	
Upstream migration facility (UMF)	is: yes new: Please select
Nature-like UMF	is: no new: Please select
Discharge in UMF (m³/s)	is: NA new: Please select

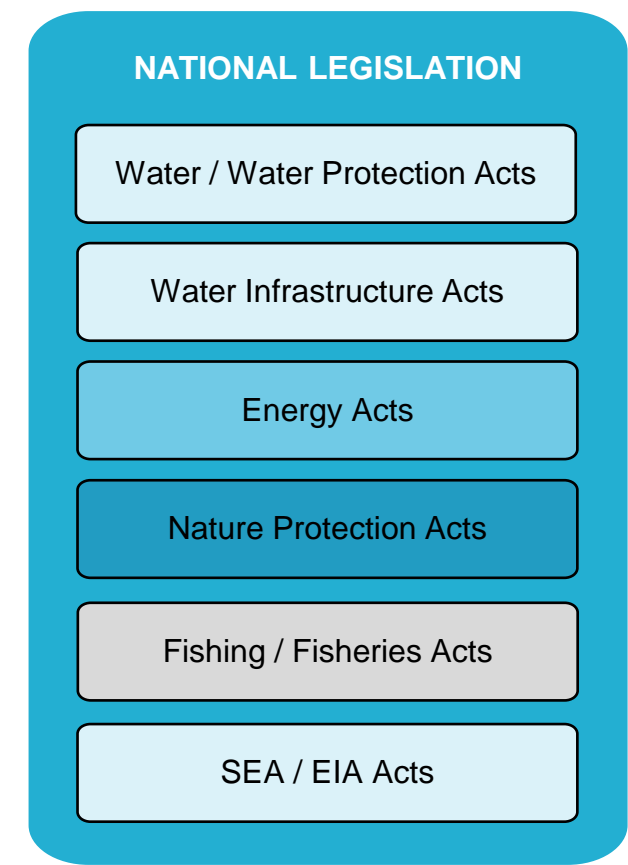
This panel will feature more simulation options in future iterations

Excel tool

REVIEW OF NATIONAL POLICY REQUIREMENTS

POLICY REVIEW IN EIGHT COUNTRIES

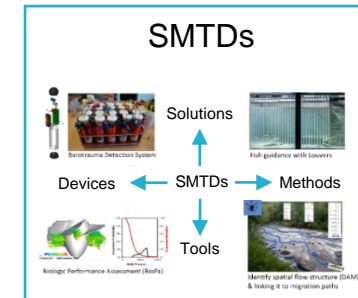
- * Countries: Norway, Sweden, France, Portugal, Spain, Germany, Switzerland, Austria
- * WFD and recently revised national acts as strong drivers for modifying the commissioning and permitting procedures for HPP (inclusion of mitigation measure requirements).
- * Mitigation of disrupted upstream fish 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



TECHNOLOGICAL IMPACT & KEY OUTPUTS

- * **State 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



Decision Support System

online

FiTHydro wiki

online

Fish Population Hazard Index

online

Cumulative Impact Assessment

Each barrier has:
 - Upstream Fish Passage Rate
 - Downstream Fish Passage Rate
 - A total upstream river length (a proxy for flow to attract fish)

Impacted reach between two HPP schemes the upper with a bypass channel

Each barrier reach sub-catchment has:
 - Length (area of river)
 - Suitability proportion for spawning & juveniles
 - Average channel width
 - Upstream spawning and nursery habitat inaccessible because of HPP barriers

Hydropeaking Impact Assessment Tool

Vulnerability	Hydropeaking effects			
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Moderate 10-15	Red	Orange	Yellow	Green
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FURTHER INFORMATION:
www.fithydro.wiki

SOLUTIONS

- * Structural improvements
- * Fish guidance and protection
- * Efficient fish migration solutions

TOOLS

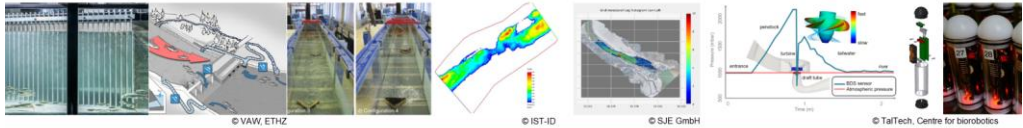
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DEVICES

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26/02/2025

7

XFLEX HYDRO ABOUT FULL-SCALE APPLICATIONS KNOWLEDGE HUB KEY PUBLICATIONS SIGN-UP

FEATURED

ARTICLE
Creating an Ancillary Services Matrix
Understanding the power and energy services needed to balance the grid, both now and in the future, is an important first step.
[Read the article](#)

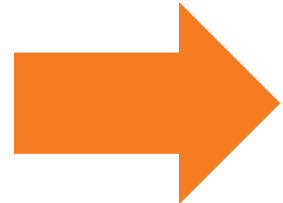
REPORT
Deliverable D1C3 Technical White Paper
[Read the report](#)

REPORT
Recommendations towards the deployment of hydropower flexibility technologies
[Read the report](#)

REPORT
Flexibility, technologies and scenarios for hydropower report
[View report](#)

FiThydro

XFLEX Hydro



Demonstration of sustainable hydropower refurbishment

Logos include: Lyse, NINA, SINTEF, AkerSolutions, intoto, HM, VOITH, vöbe, iha, EDF, ENGIE, CAR, INRAE, SuperGrid Institute, GE, edp, edp Lobelec, ALPIQ, EPFL, ANDRITZ, Hes-so, HYDRO EXPLOITATION.

