LIFE4FISH

Salmon smolt and silver eel protection at HPP in the River Meuse, Wallonia

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Profish : Sonny Damien, Lerquet, M.; Roy,R.; Colson, D.. & Beguin, J.
Unamur : P. Kestemont, I. Ben Amar, J. Lucas (University of Namur).
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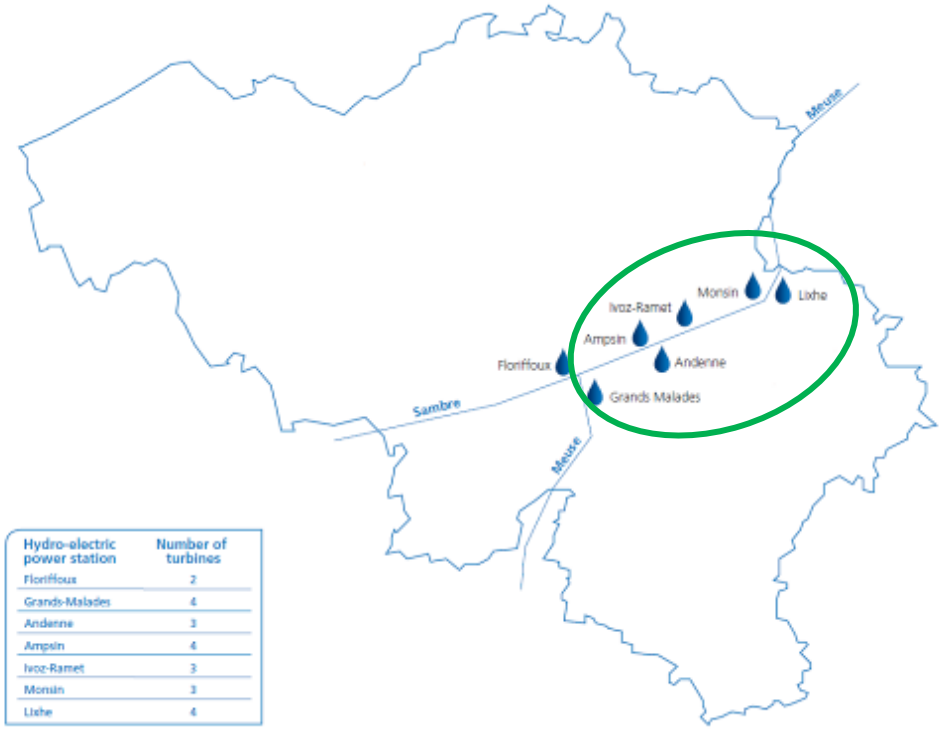
Webinar EG FISH – ICPR 15-16 September 2021

1. Context of the project



Hydro-electric power station	Number of turbines
Floriffoux	2
Grands-Malades	4
Andenne	3
Ampsin	4
Ivoz-Ramet	3
Monsin	3
Lixhe	4

83 km long-stretch between Namur and Lixhe
Concrete –channelised river
6 HPP Dams (annual levelized production 245 GWh).

Since 15 years, fish protection impositions in new permits dedicated site by site.

Salmon : >90% of the population is concerned by 2 sites Monsin and Lixhe.

Eels : population distribution in the river catchment in not sufficiently documented. Number of juveniles in drastic decline.

2. Objectives of the initiative

Project objectives:

- Increase the survival rate of silver eels > 80% and salmon smolts > 90%.
- Optimize the renewable energy produced and the balance between loss of green energy (< 5% as a target) and biodiversity.
- Integrate ecological processes or devices into the regular operational management of HPP, fish become an industrial variable influencing production decisions.
- Demonstrate the performance and transferability of the deployed solutions.
- Establish and demonstrate the value of a River Meuse stakeholder committee.
- Establish a benchmark

The solutions consist of 4 specific technologies :

- Turbine shutoff/reduction strategies driven by fish migration prediction models
- Repulsive barriers
- Fish passage facilities (bypass, adapted spillage associated with prediction models)
- Upgrade sites with new type of turbine with less impact on fish (eco-sustainable design)

3. Timeline of the project

Phase I. Diagnostic phase on the field	2017-2018
Phase II. Establishment of the reference state	2018-2019
Phase III. Development of solutions	2018-2019
Phase IV. Test of solutions at pilot scale	2019-2021
Phase V. Deployment of best solutions developed at full scale	2021-2022
Phase VI. Verification of the efficiency at the global scale	2022-2023

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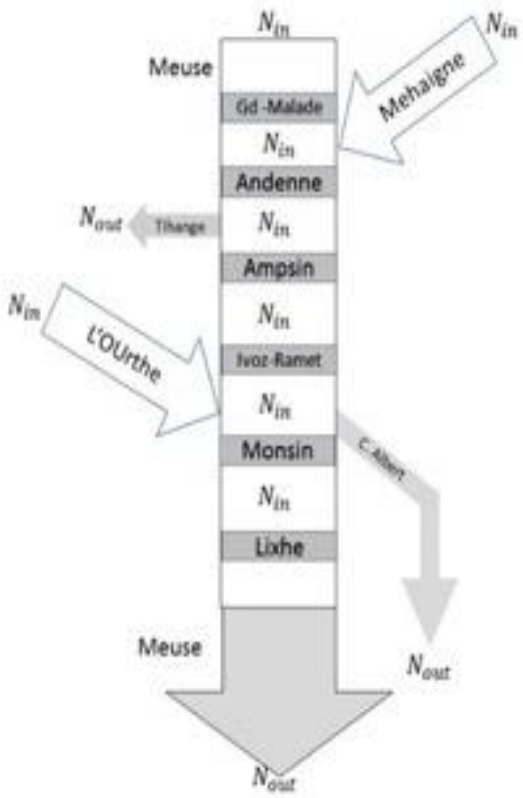
4. Diagnostic phase on the field (Phase I)

Based on measured fish passage proportion and fish survival rates for turbine passage, the reference state has been established for both species at :

1) The site scale : observed by telemetry fish passage distribution between turbine and spillways in different hydrological conditions for each site

2) The reach scale : observed by telemetry assessing the impact on fish migrating between 2 dams (predation, fishing, stop of migration, …)

3) The sub-basin scale : global impact of the 6 sites taking into account fish population input and output along the 6-sites stretch and their sanitary conditions before and after turbine passage



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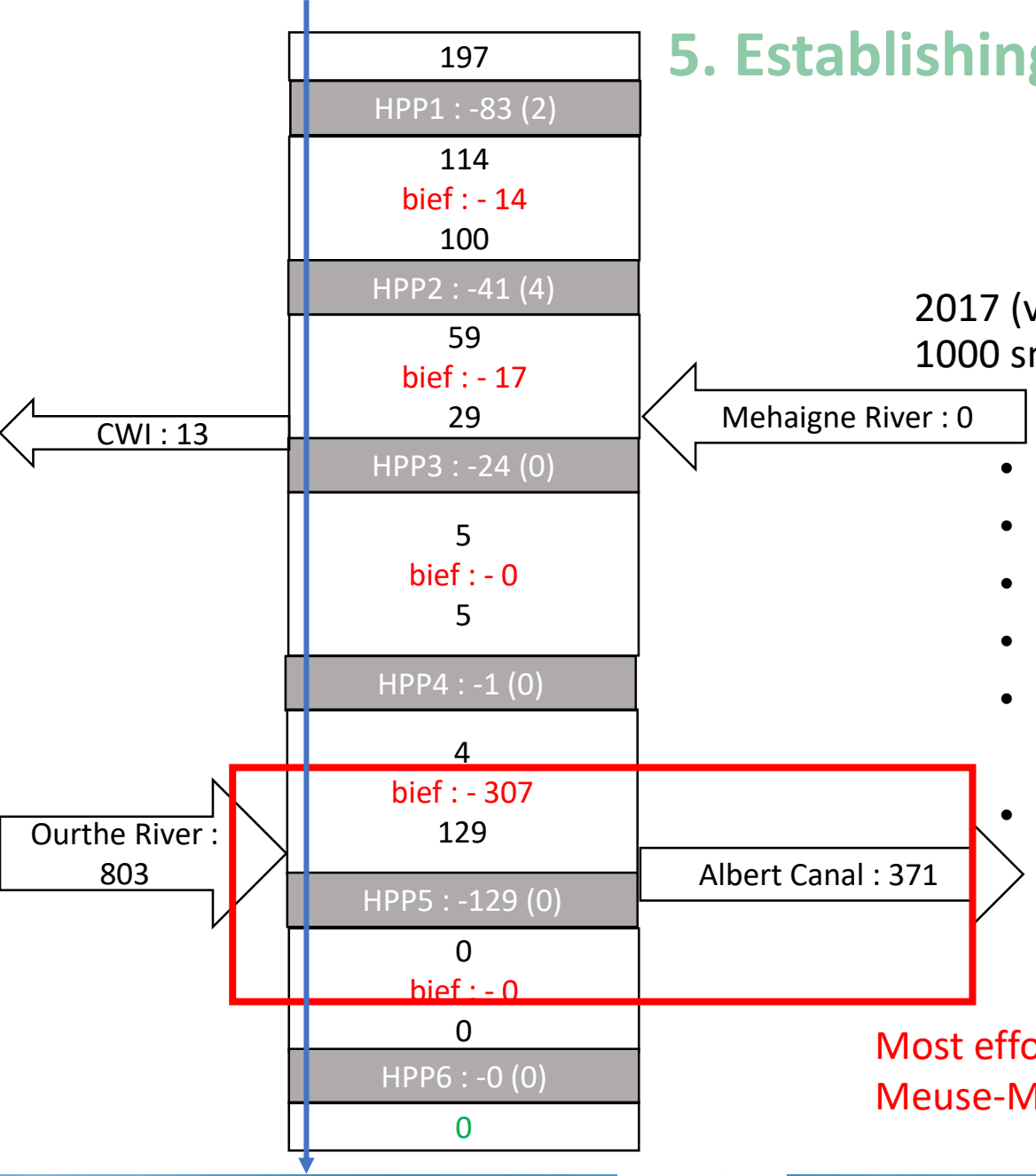
5. Establishing of the reference state (Phase II)



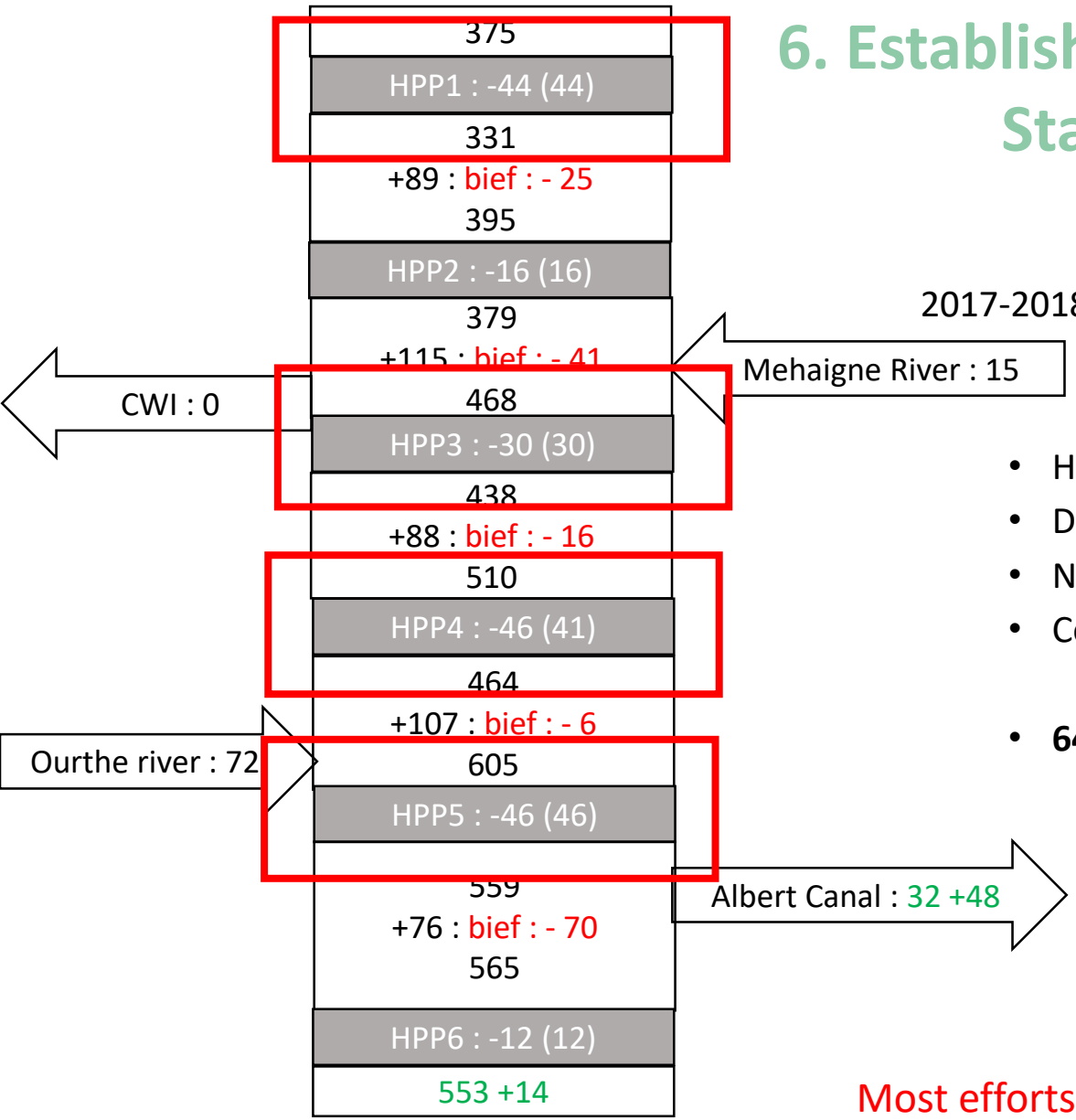
2017 (very dry spring) smolt situation (for 1000 smolt)

- Albert Canal: 37,1%
- Disappearance in reaches : 33,8%
- Non-passing fish: 27,2%
- Cooling Water Intake : 1,3%
- HPP impact: 0,6%

- **0% success of migration downstream the last HPP (Lixhe), > 90% of success as target!**

Most efforts to be done on the Ourthe-Meuse-Monsin and Albert canal junction !!

6. Establishing of the reference State (Phase II)



2017-2018 situation for 1000 silver eels

- HPP impact: 18,9%
- Dam passage and reach impacts : 15,8%
- Non-passing rate: 0,5%
- Cooling Water Intake : 0%

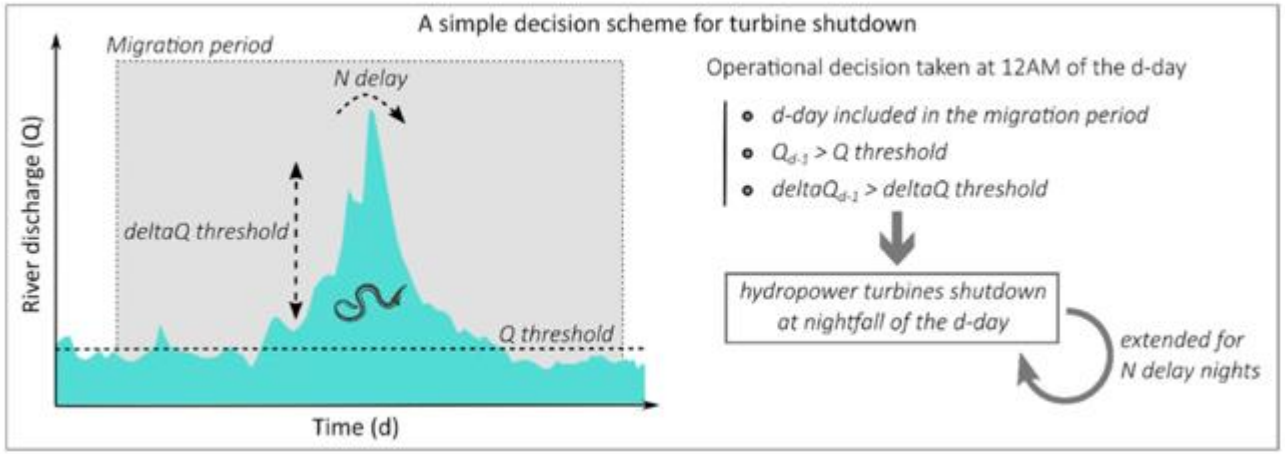
- **64,7% of migration success**
  - **>80% of success as a target**

Most efforts to be done on HPP Grands-Malades, Ampsin, Ivoz-Ramet, Monsin.

7. Development of solutions (Phase III)

Development of models to predict downstream migration days of **<u>silver eels</u>**

Silver eel : decision scheme based on (Teichert et al. 2020):



Journal of Environmental Management 261 (2020) 110212

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

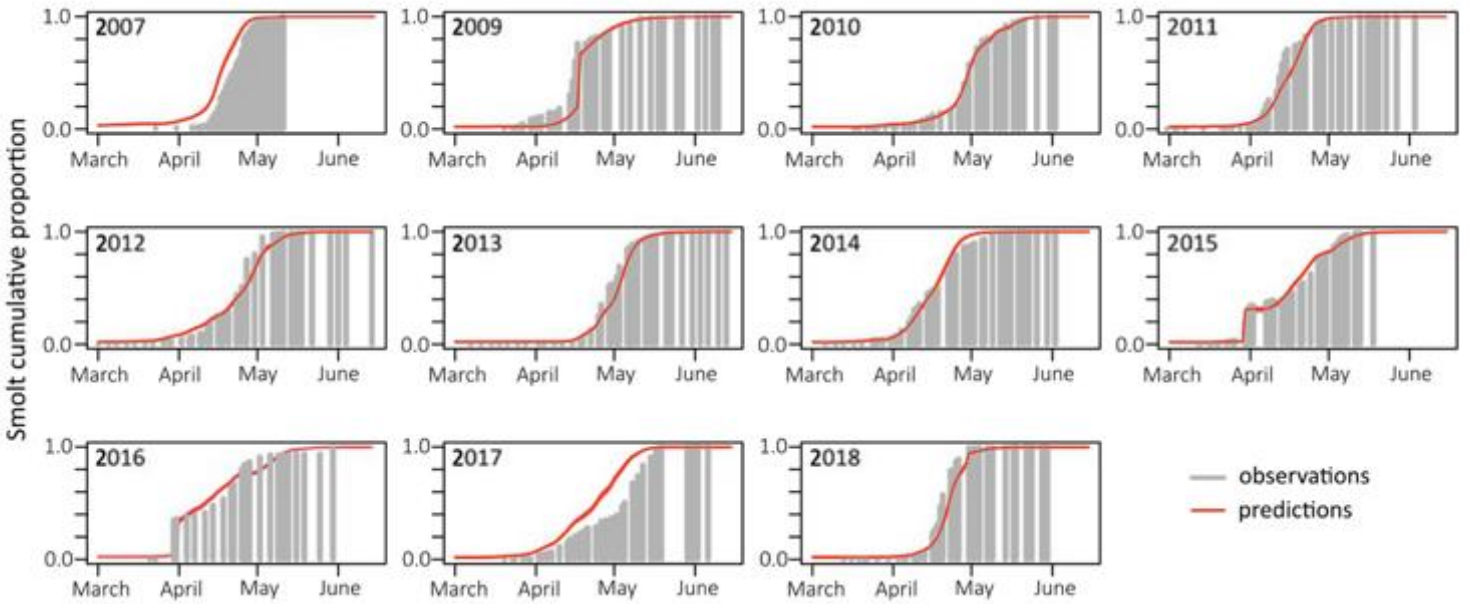
Research article

Resolving the trade-off between silver eel escapement and hydropower generation with simple decision rules for turbine shutdown

Nils Teichert [a,*], Stéphane Tétard [b], Thomas Trancart [a], Eric Feunteun [a], Anthony Acou [c,d], Eric de Oliveira [b]

8. Development of solutions (Phase III)

Development of models to predict downstream migration days of **<u>salmon smolt</u>**



Model influenced by T° and discharge of the Ourthe River, main source of smolts

Received: 13 June 2019 | Revised: 17 February 2020 | Accepted: 24 April 2020
DOI: 10.1002/wqc.3382

RESEARCH ARTICLE

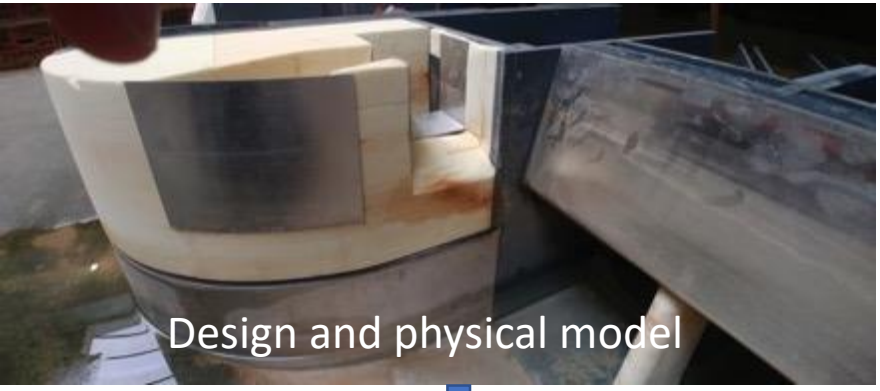
WILEY

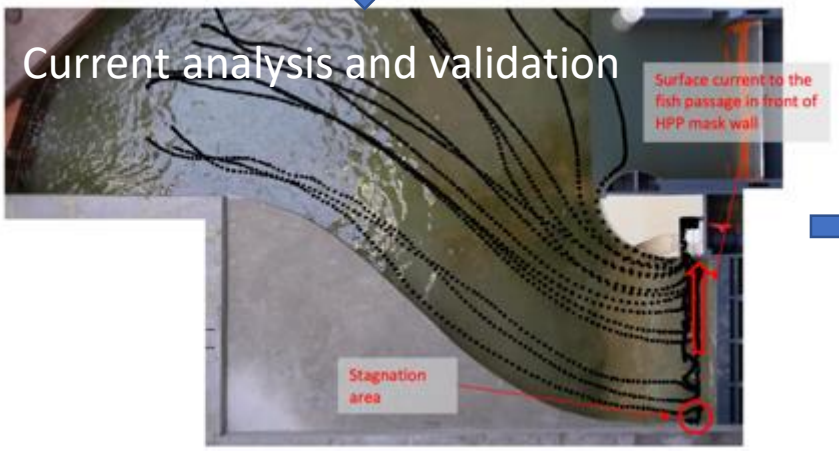
Development of an accurate model to predict the phenology of Atlantic salmon smolt spring migration

Nils Teichert[1] | Jean-Philippe Benitez[2] | Arnaud Dierckx[2] | Stéphane Tétard[3] | Eric de Oliveira[3] | Thomas Trancart[1] | Eric Feunteun[1] | Michaël Ovidio[2]

9. Development of solutions (Phase III)

Numerical and physical models of HPP to support and verify the design and the hydrological impoundment of bypass to be implemented at some sites

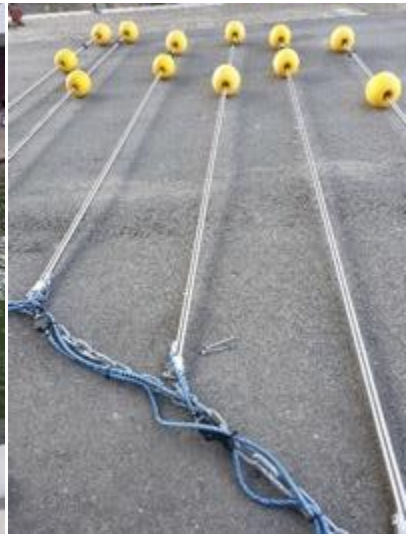


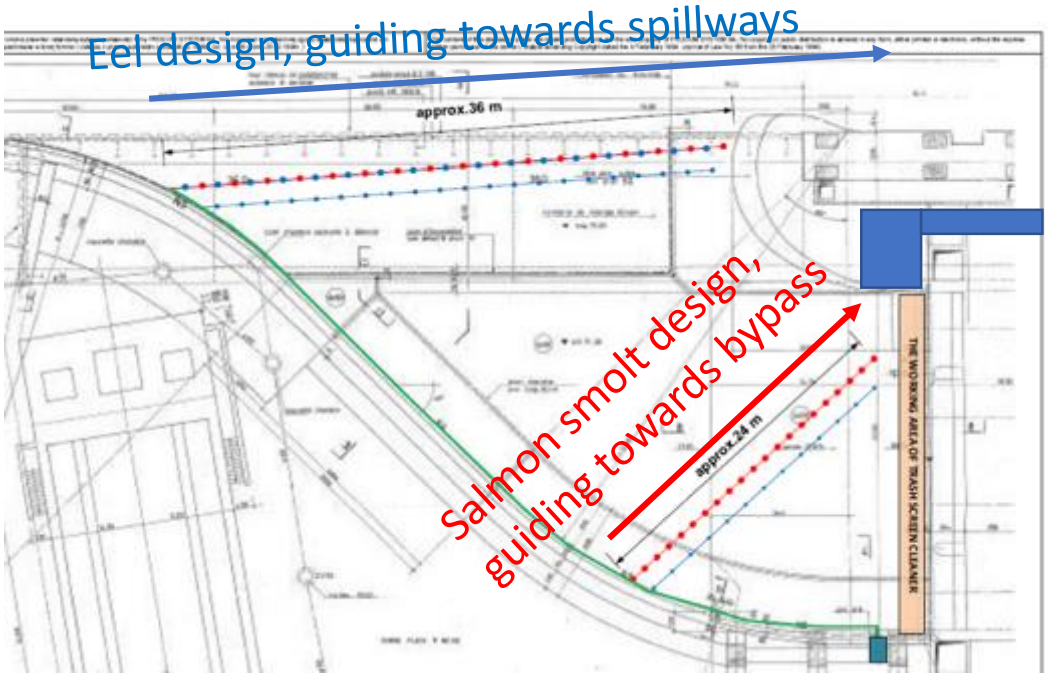


10. Development of solutions (Phase III)

luminus Behavioural guiding barriers : market analysis and test on best proposed offers

1) Electrical barrier : Neptun system, by Procom Systems (PL), tested on HPP1

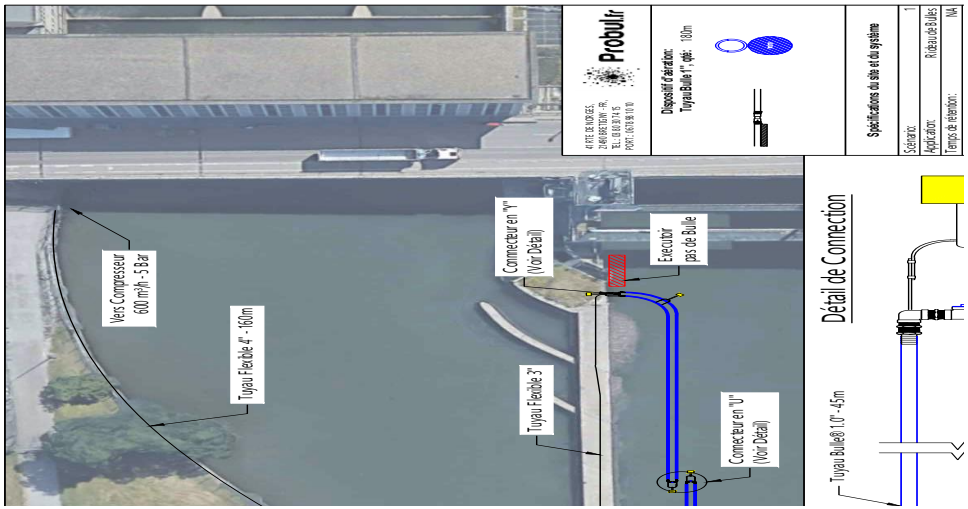




11. Development of solutions (Phase III)

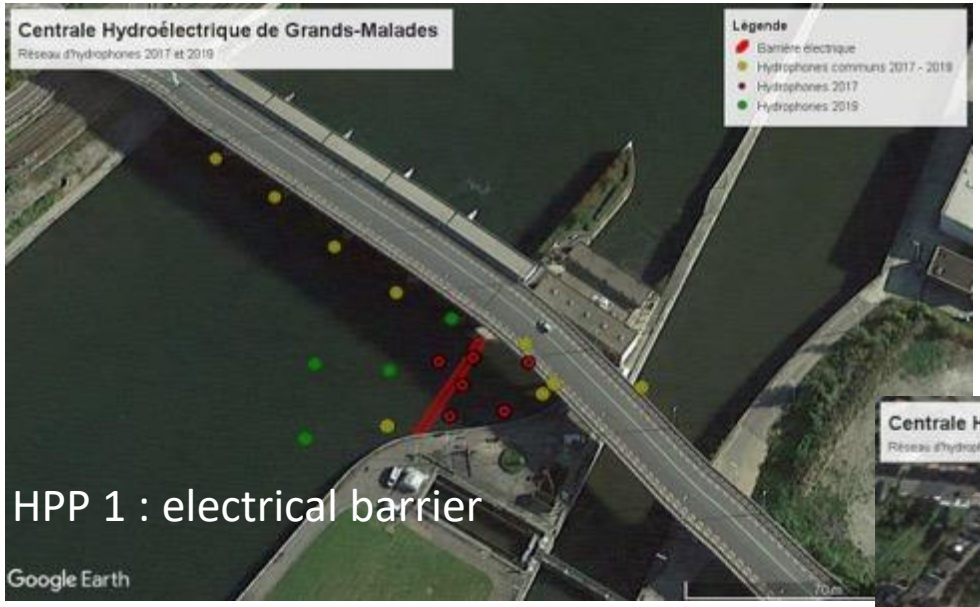
luminus Behavioural guiding barriers : market analysis and test on best proposed offers

2) Bubble fence : Provided by APUMAS, tested on Ivoz-Ramet

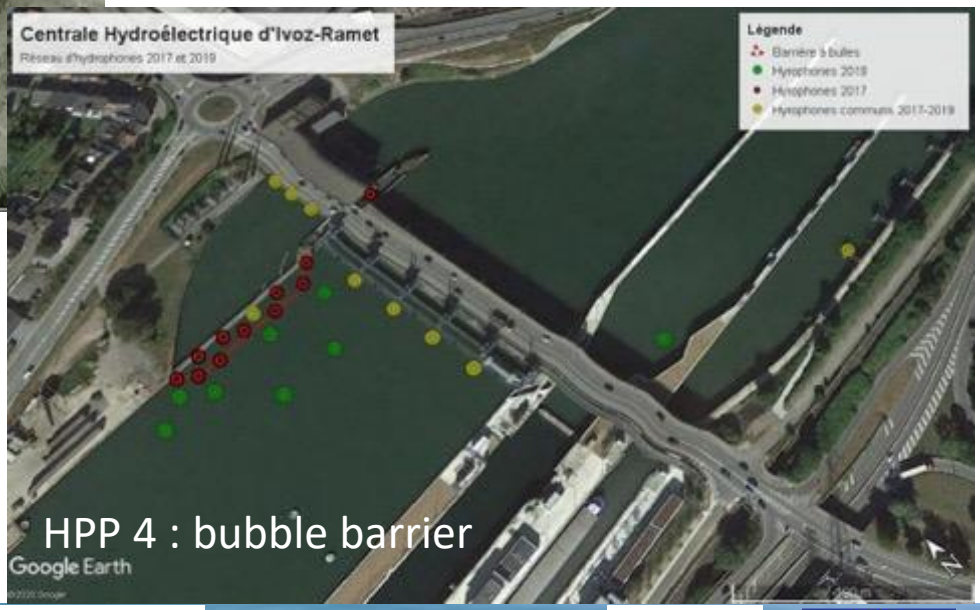


12. Tests of solutions at pilot scale (Phase IV)

Passage and behaviour have been monitored by acoustic telemetry
Silver eels in 2019, Salmon smolts in 2021
Pilot sites : HPP Grands-Malades, Andenne, Ivoz-Ramet + normal operation at other HPP



HPP 1 : electrical barrier



HPP 4 : bubble barrier

13. Tests of solutions at pilot scale (Phase IV)

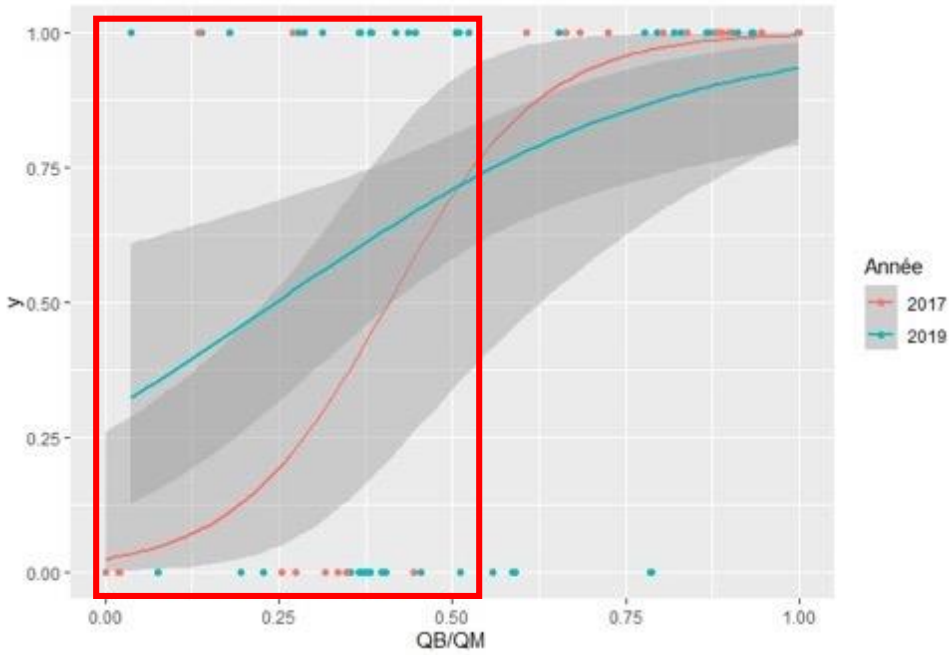
A) Electrical barrier at Grands-Malades (HPP 1)

Natural escapement over the spillway in 2017 : 42 to 66% → lot of eels are passing during high discharge and are not exposed to the HPP inlet

It is important to consider the efficiency of the barrier during hydrological condition that are in favour of an acute exposition of eels to the HPP inlet :

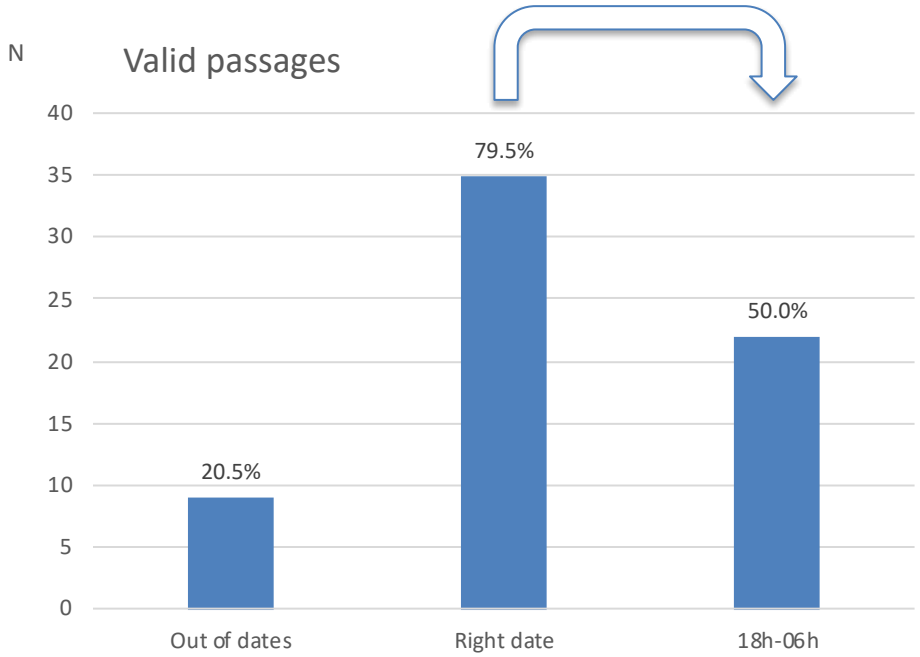
→ Q_{Meuse} < 300 m^3/s : turbine entrainment rate decreased from 82% in 2017 to 44% in 2019 = **barrier efficiency of 46%**

→ Q_{dam}/Q_{Meuse} < 0.5 : logistic model is significantly reduced by **52% (P =0.035)** and is explained by the barrier

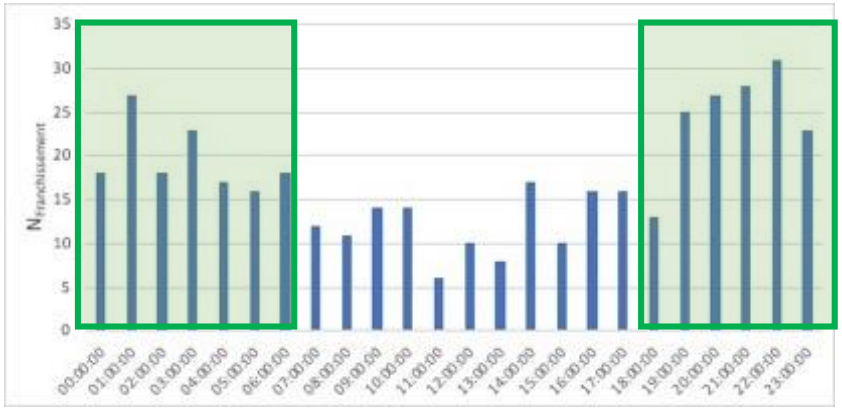


14. Tests of solutions at pilot scale (Phase IV)

B) Silver eel prediction model and turbine shutdown at HPP2



Time repartition of all eel passages at all sites in 2019



Removing eels detected < 7days after tagging and release :

- 79.5% of success of predication for the date
- 50.0% of success of prediction in the shutdown timeframe 18h-06h

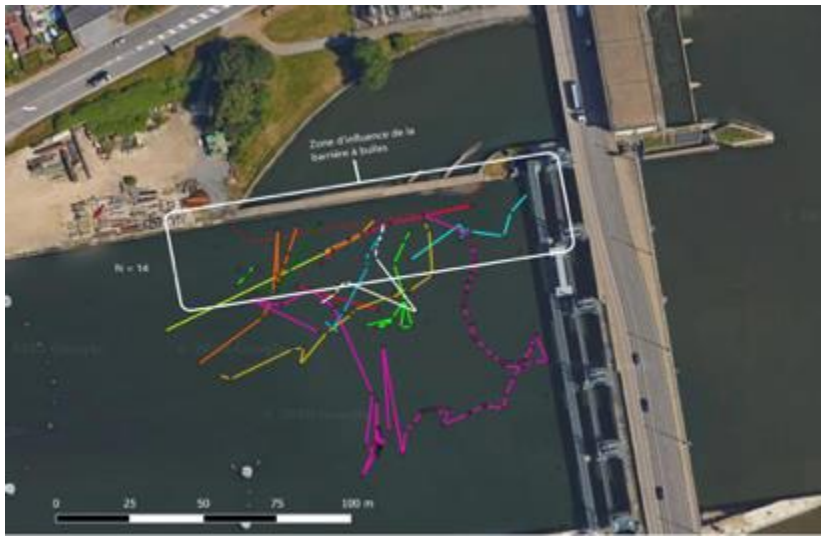
Operational shutdown was not optimum due to some technical troubles :
Temporary failure of the discharge probe, coordination with the dam operator, …

15. Tests of solutions at pilot scale (Phase IV)

C) Bubble barrier at Ivoz-Ramet (HPP 4)

In operation between 20th September to 30th November 2019, destroyed due to the poor of the device.

During this shortened period, 15 eels crossed the site through the HPP, but for most of the eels, the HPP was the only route to take, spillways being closed during low discharge.



No real avoidance has been observed due to the bubble barrier.

16. Tests of solutions at pilot scale (Phase IV)

Conclusions for silver eels

A) Neptun electrical barrier : efficiency of ≈ 50%

B) Prediction model : theoretical efficiency of ≈ 50%, but needs an operational improvement

C) Bubble barrier : no observed efficiency due to the poor quality of the device

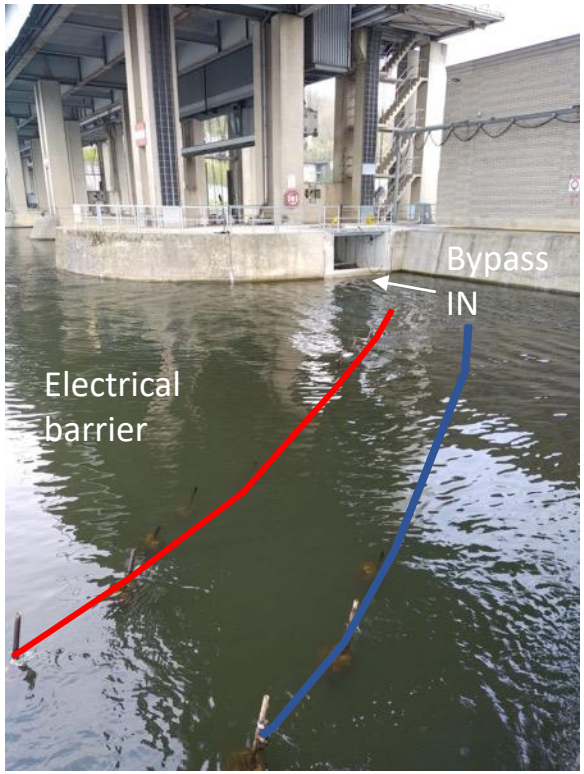
17. Tests of solutions at pilot scale (Phase IV)

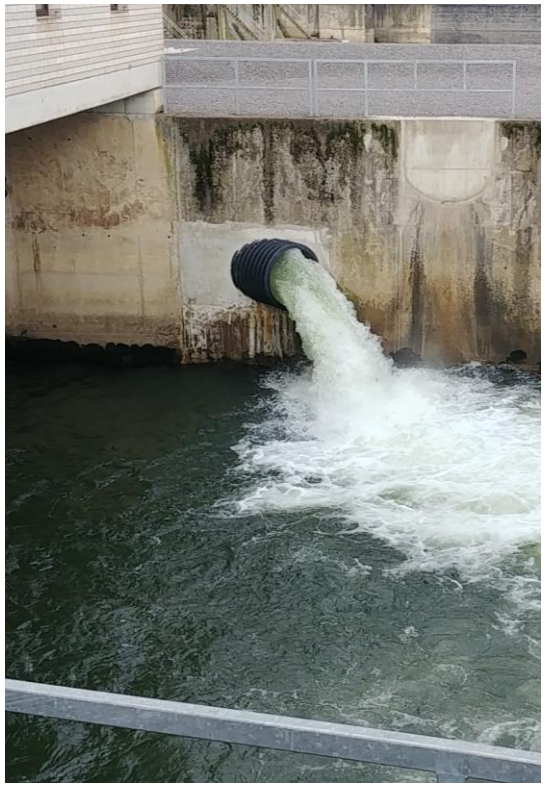
B) Salmon smolts

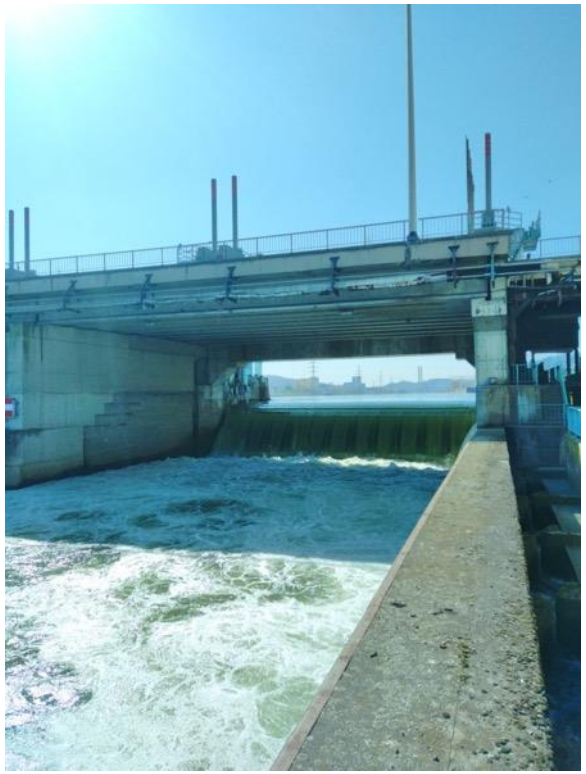
Passage and behaviour have been monitored by acoustic telemetry

Grands-Malades (HPP 1) : Bypass + Neptun electrical barrier

Ivoz-Ramet (HPP 4) & Lixhe (HPP 6) : concentrated spillage of 50 cm & 90 cm at Ramet 20 cm at Lixhe

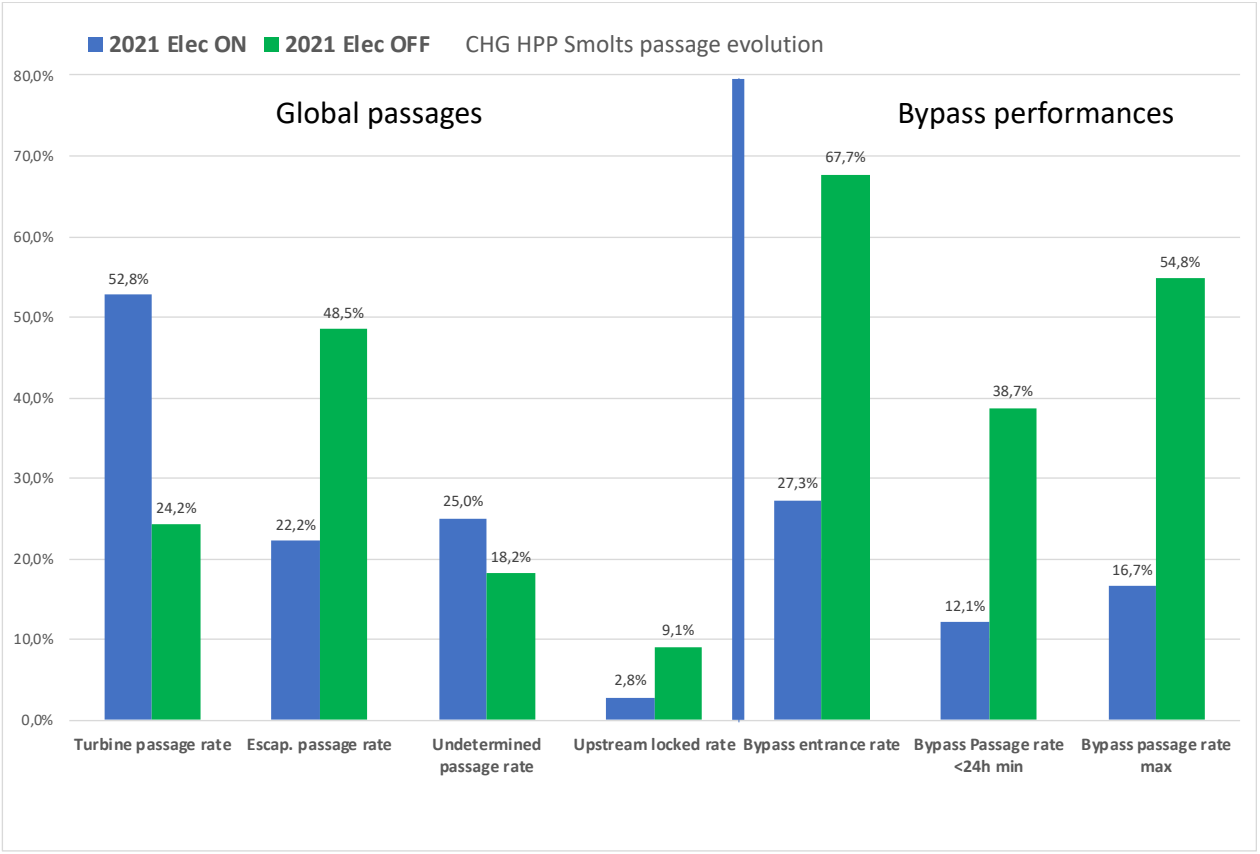






18. Tests of solutions at pilot scale (Phase IV)

Bypass + Electrical barrier at HPP1



ELECTRICAL BARRIER ON :

Entrance efficiency : 27%

Bypass efficiency : 12–17%

ELECTRICAL BARRIER OFF

Entrance efficiency : 68%

Bypass efficiency : 39-55%

Entrance rate > passage rate?

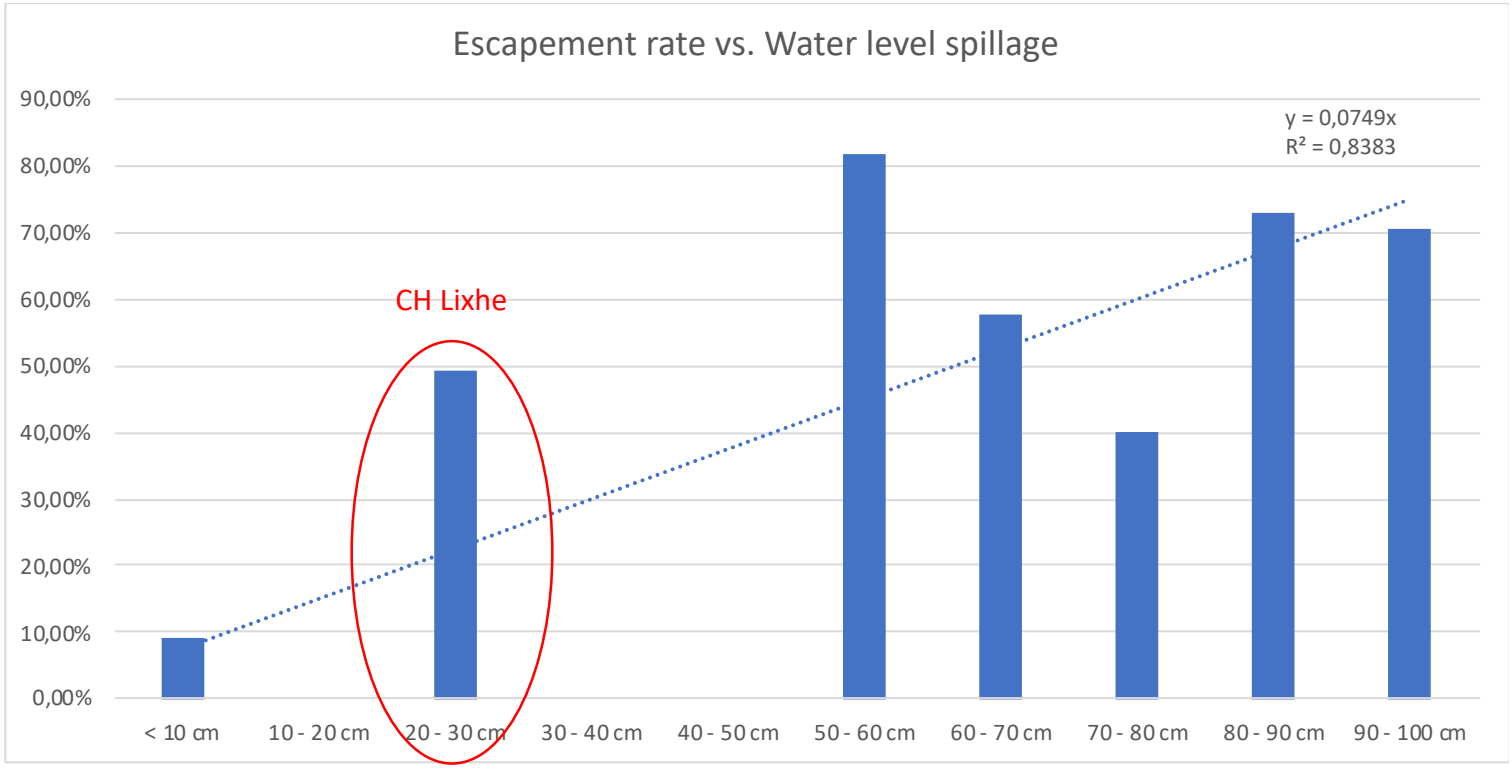
→ Debris clogging?

→ The electrical barrier obviously did not help salmon to find the bypass, and could have had a opposite effect. High voltage with too much repulsion/attraction?

→ Behavioural studies ongoing to determine the effect of the barrier on smolt behaviour, the results do not means that the barrier has no effect at all.

19. Tests of solutions at pilot scale (Phase IV)

Adapted spillage



Smolt passage by spillage ranged betwen 40% and 80%
Spillage of 20-30 cm at Lixhe reached a similar efficiency than the bypass at Namur

More detailed behavioural analysis under process

20. Deployment of best solutions developed at full scale (Phase V) & Verification of the efficiency at the global scale (Phase VI)

A) Full scale implementation during summer 2022 :

Options are in discussion :

Site	Eels	Salmon
Grands-Malades HPP1	Electrical barrier	Bypass (from pilot tests)
Andenne HPP2	> 90% of natural escapement observed : no protection	No ecological need (may change, pending on the restocking policy)
Amspin HPP3	Electrical barrier or/and turbine management?	No ecological need (may change, pending on the restocking policy)
Ivoz-Ramet HPP4	Turbine management	No ecological need (may change, pending on the restocking policy)
Monsin HPP5	Turbine management (if required with new turbines)	Spillway management with model
Lixhe HPP6	> 90% of natural escapement observed : no protection	Bypass vs adapted spillage (cost efficiency balance)

B) Monitoring of the solutions deployed at full scale for silver eels (2022-2023) and salmon smolts (spring 2023)

C) Closure of the project : September 2023, we are optimistic in the capacity of the project to meet the objectives.

VII. Next steps

The after life phase :

- A significant impact has been observed for silver eels on spillways (5-10%) at some dams… Towards a new issue : fish-friendly dams?

- The LIFE4FISH partners have now accumulated lot of experiences, and their synergy can be available for other users : Power companies with several HPP on the same basin, public authorities for upstream-downstream continuity, …

Feel free to contact us to discuss possible collaborations!

In the meantime, all reports and additional information are available at :

https://www.life4fish.be/