LIFE4FISH

DOWNSTREAM MIGRATION OF SALMONS AND EELS ON THE LOW MEUSE

LIFE 16NAT/BE/000807

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IN A NUTSHELL

The LIFE4FISH project has aimed to test and validate innovative approaches for hydropower plant management during the downstream migration of two reference species: the European eel (*Anguilla Anguilla*) and the Atlantic salmon (*Salmo salar*). It was conducted on the Meuse river in Wallonia, with the objective of reconciling the production of renewable energy with the preservation of ecological continuity.

In order to facilitate the passage of these fish, the project partners have developed a system for automated turbine stoppages and dam openings, based on a novel model for predicting downstream migrations. It was accompanied by the installation of equipment to guide the fish towards less impactful passages: downstream fish pass and behavioural barriers. These three techniques tested by the project were previously unprecedented on the Meuse river.

They have been complemented by the installation of two “eco-sustainable” turbines in Monsin, which constitutes a European first. This equipment was specifically developed to lower the impact of hydropower turbines on the passage of fish. It complements the preservation techniques experimented by the LIFE4FISH project.

All these solutions are based on the physical and numerical modelling of water flows around the infrastructure, as well as on biological analyses of fish populations. They have been validated by an acoustic monitoring network located upstream and downstream the infrastructure. They allow for a better understanding of interactions between the fish fauna and hydropower plants on the Low Meuse, for a better protection of biodiversity.

The objective of the LIFE4FISH is to increase the rate of successful downstream migration by these two species and to reach a final result of 80% for eels and 90% for smolts, with limited losses in renewable energy production. The project has fully demonstrated its success and its potential. Based on a range of solutions for infrastructure management and adaptation, LIFE4FISH paves the way for a new approach of fish continuity on the Low Meuse.

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THE PARTNERS

LUMINUS, lead partner of the consortium, is an electricity producer and energy supplier. It is the main operator of run-of-river hydropower plants in Belgium, with a total installed capacity of 67 MW. LUMINUS brings in the expertise and knowledge related to investment, operation and maintenance operations of hydroelectrical infrastructure.

EDF R&D: the National Laboratory on Hydraulics and the Environment (LNHE) of EDF R&D is involved in all aspects of water and the environment interacting with hydropower production. Its missions include the environmental acceptability of power plants for the aquatic environment and the optimisation of power production capabilities.

PROFISH TECHNOLOGY is a spin-off the Liège University created in 2007, specialising in the monitoring of fish populations. As part of the project, PROFISH TECHNOLOGY's mission consists in measuring the successful migration of salmon smolts and silver eels across the hydropower plants operated by LUMINUS.

UNIVERSITY OF LIEGE: the research group on Hydraulics in environmental and civil engineering (HECE) of the Liege University develops and applies hybrid modelling approaches, numerical and experimental, to the understanding of flows from the rain drop reaching the ground to its return to the sea.

UNIVERSITY OF NAMUR: the Institute of Life, Earth and Environment (ILEE) of the University of Namur studies the evolution of populations, organisms and ecosystems, and is involved in the development of sustainable solutions with ecological, technological, socio-economic, historical and cultural perspectives.

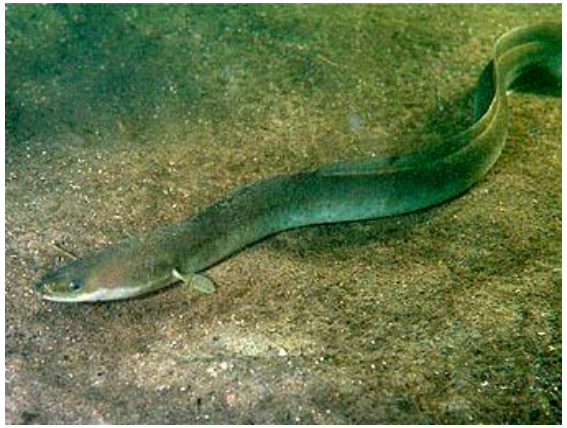
LIFE4FISH

Co-funded by the European Union

A project co-funded by the LIFE programme

The European Union finances environmental, climate and nature preservation projects through the LIFE programme. This programme was set up in 1992 to finance projects within the entire European Union, as well as in neighbouring countries.

The Atlantic salmon is listed on the IUCN Red List of endangered species. Its restoration in Wallonia is pursued since 1983 by the “Meuse Saumon 2000” programme



The European eel is a critically endangered species, protected by the European “Eel Regulation” (1100/2007/EC)

WHY THE PROJECT?

European eels and Atlantic salmons are diadromous species, meaning that they need to move from rivers to the sea to develop, reproduce and complete their biological lifecycle. These two species however have different types of journeys:

- The Atlantic salmon is anadromous: it hatches in rivers and stays in freshwater for one to six years. As it becomes a smolt, it migrates to the ocean where it lives for a few years before going back to the river where it was born to procreate. It can undertake such migrations two to three times.
- The European eel is catadromous: it is hatched in the sea, becomes a transparent larva before swimming up a river where it develops as a yellow eel. It returns to the sea as a silver eel to lay eggs and die. This cycle can represent up to 10,000 km.

The population of Atlantic salmons and European eels is declining globally, due to a number of man-made pressures. On the Meuse, salmons have been extinct for decades and the population of eels is reducing dramatically. Both species are protected in Wallonia: they cannot be fished, and important environmental programmes are conducted to reintroduce them. When issuing permits for operating hydropower plants, the Wallonia region defines maximum mortality targets for these species.

The project was conducted on all six hydropower plants on the Belgian Meuse: Grands-Malades, Andenne, Ampsin-Neuville, Ivoz-Ramet, Monsin and Lixhe.

Ecological continuity of rivers

The European Water Framework Directive (2000/60/EC) sets an overall objective of achieving a “good ecological status” of rivers. This includes ensuring their ecological continuity: allowing water, aquatic organisms and sediments to move freely. This movement can be affected by constructions such as dams, locks, dikes, artificial banks and water quality, and require measures to restore ecological continuity.

Hydropower production

Hydropower is one of the main sources of renewable energy in Europe. It represents 7% of the electricity consumed and 32% of renewable electricity. In Belgium, run-of-river hydropower produces 330 GWh per year. This renewable energy is an undeniable asset for the energy mix: it is predictable, does not emit greenhouse gas and contributes to energy independence and security of supply as it does not depend on hydrocarbon imports.

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OBJECTIVES

The project aims to improve the protection of European eels (*Anguilla Anguilla*) and Atlantic salmons (*Salmo salar*) with innovative measures for fish passage across water infrastructure (dams, locks, hydropower plants) and to improve ecological continuity on the Meuse river.

The objective of LIFE4FISH is to reconcile the requirements of renewable energy production with the preservation of these species, specifically aiming to:

- Increase the survival rate of eels and smolts by respectively 80% and 90% during their downstream migration on the Low Meuse;
- Identify the downstream migration periods and the factors that influence them (water flow, moon phases, temperature, turbidity) in order to better anticipate them;
- Integrate fish migration forecasts into the piloting of hydropower plants with targeted turbine stoppages, complemented by other preservation measures that maintain the hydropower production capacity;
- Demonstrate that these solutions can be efficiently combined, but also used on other rivers;
- Associate a committee of stakeholders of the Low Meuse for the implementation of new actions.

The first step of the project has been to assess the status of salmon and eel populations transiting through the project zone in order to better understand the factors influencing their passage through each power plant.

Population statuses and migration periods

A biological analysis was conducted to provide an estimate of eel and salmon populations on the Low Meuse, and to describe their physiology, health and migratory capability. Samplings with capture, tagging and re-capture at each dam after the passage of eels and salmons were compared to various environmental factors influencing their movements, such as temperature and water flow. It enabled to describe the environmental conditions of downstream migration periods on the Low Meuse (March-May for salmon smolts, October-January for silver eels), and to establish a population status different than the one previously communicated by the Service Public de Wallonie.

The monitoring of downstream migration has included the detection of descent pathways by acoustic telemetry, with releases of fishes equipped with chips and the installation of hydrophone to track their position, as well as the measurement of the impact of turbines by injections upstream the turbine. The health condition of fishes after passing a plant was studied using fish injections and recapture at 24h, 48h and 72h intervals.

Influence of water flows on fish passage and impact of hydropower plants

The LIFE4FISH project has analysed the influence of river obstacles and water flows on the passage of salmon smolts and silver eels. Multiple variables and configurations have been studied: water level, water flow, turbine operation, dam opening… A specific point for attention was that other constructions than hydropower plants can affect fish passage, such as dams, forebays or locks for navigation. This contributed to defining measures for a less impactful passage: stopping the turbines, requesting an opening of the dams, constructing fish passes, and/or installing behavioural barriers to guide the fish.

AUTOMATED HYDROPOWER PRODUCTION RULES

Developing a numerical downstream fish migration model

By considering all environmental factors that signal the start of a migration event upstream the hydropower plants, LIFE4FISH has developed a numerical model that identifies critical downstream migration periods. Forecasting these events is based on a statistical analysis:

- Analysis of the phenology of eels and salmons on the Low Meuse, i.e. the variations of periodic phenomena such as migration. It identified peaks in river flows as a major factor for the start of eel and salmon migrations. Temperature, moon phases and water turbidity are other contributing factors.
- Analysis of the speed at which the species are moving and their trajectories, to determine when they approach the power plants.

The model is enriched by historical data on environmental conditions and catching campaigns.

Automated piloting of hydropower production

The numerical model for downstream fish migration provides the hydropower plant operator with the necessary information to adapt the management of energy production in order to facilitate the passage of species. It determines the periods when turbines need to be stopped. Different threshold levels for migration were tested, then integrated into the piloting parameters: low values, signalling a limited migration phenomenon, would lead to an excessive reduction in electricity production, while high values would lead to a greater impact on species. The predictive model enables operators to integrate information on downstream migration in the piloting of hydropower production.

This automated system thus is a decision support tool that integrates migratory phenomena in the piloting of hydropower plants. The system was installed in the control room that coordinates the operation of the six hydropower plants. The project included the training of operators on the numerical model for downstream fish migration and on actions to be integrated into the management of the power plants.

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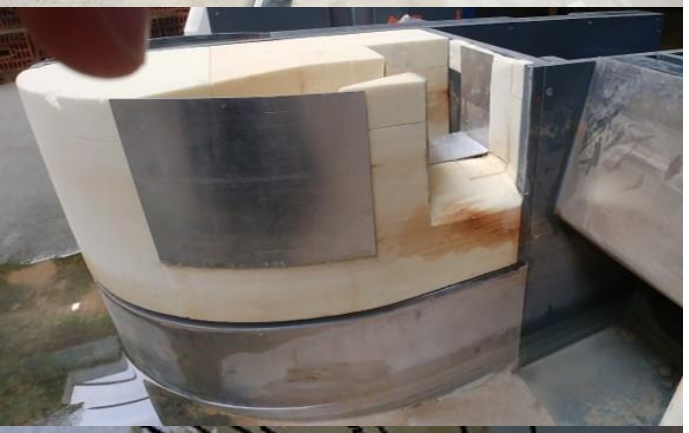

Andenne, Grands-Malades and Ivoz-Ramet as pilot sites

Measures to reduce the impact of hydropower plants were first tested, then optimised and replicated on other project sites. The prediction of migration periods has been tested in Andenne, the fish pass and behavioural barriers in Grands-Malades and the bubble barrier in Ivoz-Ramet.

The Grands-Malades and Ivoz-Ramet pilots have been prepared by hybrid modelling: they combined a numerical model of the power plant and an experimental model reproducing it at small scale. Hydraulic characteristics such as the water flow or the direction of currents were assessed against fish behaviour in order to identify the factors that influence their trajectories. This helped optimise the position of the fish pass and location of behavioural barriers.

Continuous monitoring of the efficiency of solutions

A telemetric monitoring of migrating fishes was put in place for a continuous observation of the improvement of passages. The monitoring of salmons and eels during the test phase and then during the full deployment has thus created an improvement loop for all the solutions tested by the project.

The project has assessed the socioeconomic benefits of fish preservation measures, considering the effects of renewable power production losses, the impact of the project on research, employment and investment, and the societal value of protected fish species in Wallonia.

An assessment of the impact of the project on ecosystem functions was also conducted.

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INSTALLING INNOVATIVE EQUIPMENT

Downstream fish pass

The downstream fish pass is an opening that bypasses the turbines. Placed near the entrance of water intakes, it directs the fish towards a specifically designed passage. The fish pass needs to create a water flow that attracts the fish towards a safe passage, while minimising the losses in water required to produce electricity.

The water flow at the entrance of the pass needs to be sufficiently progressive for fishes to face the passage and not be dissuaded by an excessive speed or turbulences. When crossing the fish pass, they are transferred downstream the power plant by the current.

The design of a fish pass suited for the project has required strong engineering skills for hydrology, modifications to the waterfall, valves and the development of command systems. Its installation has involved important civil works.

Behavioural barriers

The behavioural barriers guide the migrating fish towards the downstream fish pass or to existing openings such as the dam. They are located upstream the water intakes and produce stimuli that influence the behaviour of fishes and incites them to adopt a favourable trajectory.

Two types of behavioural barriers were tested by LIFE4FISH:

- Electrical barriers: they create a repulsive screen by emitting a low-voltage current that emits impulsions that can vary in amplitude,a frequency and duration;
- Bubble barriers: they are supposed to create a visual and acoustic curtain discouraging the passage of fishes at the water intake, but this system did not withstand the conditions in the Meuse and was destroyed by the river current two weeks after its entry in operation.

These innovative devices, with no impact on the health of fishes or on the environment, have been developed by adapting the results of scientific studies. They aim to complement in the best possible manner the fish passes.

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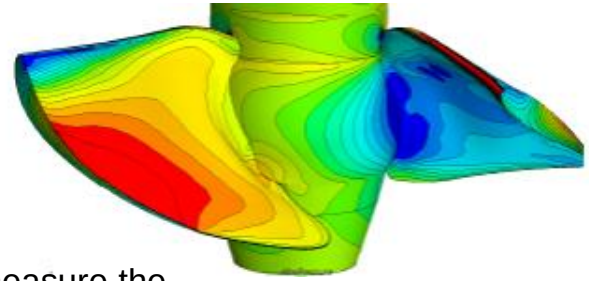
THE “ECO-SUSTAINABLE” TURBINES

A European first in Monsin

Complementing the LIFE project, two “eco-sustainable” turbines were installed in the Monsin hydropower plant. These Kaplan-type, vertical-axis turbines facilitate the passage of fishes through them. This investment was a European first for fish passage solutions. Based on the analysis of scientific research and on test labs, LUMINUS has determined the most relevant characteristics to reduce the impact of turbines. They have been integrated into a protocol for the design and development of lower-impact turbines.

The resulting “eco-sustainable” turbine has the following characteristics:

- Reduced number of blades, from 4 to 3;
- Reduced rotation speed;
- Improvement of blade profiles;
- Gaps reduced to a maximum to prevent clamping.



Testing the new turbine has included fishes equipped with sensors to measure the physiological effects of passages through turbines (pressure variations, acceleration…) and modulate the pressure to attenuate the impact on the fish.

With an impact reduction divided by three, the positive results of the eco-sustainable turbine make of it an integral part of the solutions for the improvement of ecological continuities developed by the LIFE4FISH project.

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LIFE4FISH'S ACHIEVEMENTS

The project has demonstrated the effectiveness of solutions that significantly reduce the impact of hydropower plants on the downstream migration of salmon smolts and silver eels: adapted piloting of hydropower plants, fish pass, behavioural barriers and "eco-sustainable" turbine.

The results of the measurement campaigns, coupled with modelling results, enable to estimate for the first time the actual impact of hydropower on the Low Meuse. The efficiency of the downstream migration measures deployed by the project is satisfactory for eels and smolts at the six sites with stable results, in line with preservation objectives.

The approach developed by the project optimises hydropower production during migration periods. This dynamic control strategy enables to implement ecological continuity measures while maintaining renewable energy production, in line with climate and energy objectives for Belgium and Europe. The project significantly strengthens the operational experience in the field of ecological continuity and its local characteristics, which can feed into the improvement of hydropower plant licensing and management.

More information about the project can be found at www.life4fish.be

LIFE4FISH

- A seven-year project (2017-2023)
- An impact of sites on silver eels reduced to 12.7%
- An impact of sites on salmon smolts reduced to 22.5%
- Preserved renewable energy with losses in generating capacity lower than the 5% targeted by the project
- 906 hours of cumulated turbine shutdowns at all project sites
- Five sites using predictive automated plant management

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