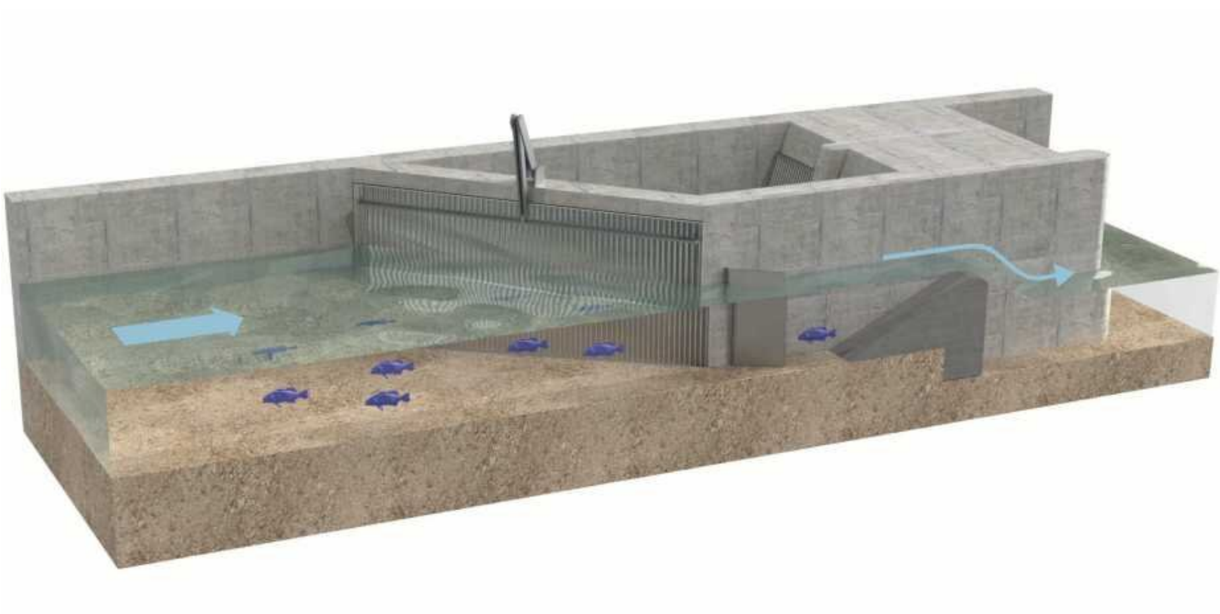
Toward more fish-friendly hydropower plants

February 11 2021, by Michael Keller



A safe guidance system for fish: a specially designed bar rack effectively guides downward migrating fish past the turbine, only slightly limiting the power plant's operations. Credit: VAW / ETH Zürich

Over the course of the EU project FIThydro, research and industry partners studied the ecological impact of hydropower plants. ETH Zurich's Laboratory of Hydraulics, Hydrology and Glaciology (VAW) has developed a protection and guidance system that can help migratory fish to safely bypass hydropower turbines.

Hydropower plants can have a major environmental impact. They dam up rivers, change aquatic habitats and hinder migrating fish, which can be injured or killed by the turbines, trash racks and flood relief systems.

The Swiss Waters Protection Act and the EU Water Framework Directive aim to mitigate these negative effects. However, many older hydropower plants in particular do not meet the new requirements—and have to be retrofitted. For each power plant, cost-effective measures must be individually determined considering its specific case.

"It's important to incorporate specific regional fish passage design that take into account the vital needs of local species, the hydraulic conditions at the site and the layout of each particular power plant," explains Robert Boes, Professor of Hydraulic Engineering and head of the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) at ETH Zurich.

A pan-European survey of hydropower plants

VAW was involved in the four-year Horizon 2020 FIThydro project funded by the European Research Council. The project team comprising 26 European research institutions and companies studied 17 sites in eight countries to examine the impact of hydropower plants on river ecosystems and in particular on fish. VAW contributed several laboratory and field studies, some in collaboration with regional partners.

By looking at the Schiffmühle plant on the Limmat river and the Bannwil plant on the Aare river, VAW and the project partners initially studied existing methods and approaches to assess the environmental impact of hydropower plants and refurbishment measures. "We wanted to identify knowledge gaps and find out how we can improve the current situation and the already implemented measures," says Boes.

Fish migrate upstream and downstream

It was unclear, for instance, which upstream and downstream bypass systems are most suitable for which fish species and which conditions are ideal for fish to find them. VAW researchers and their partners measured the flow velocities and monitored fish movements by tagging a few thousands of fish with passive integrated transponders (PIT) around the Schiffmühle hydropower plant. The monitoring showed that many fish species in the Limmat are able to effectively use the technical and near-natural fish passage solutions to move upstream.

Fish migrating downstream have to swim through the turbines of a hydropower plant if no other downstream option is available. This is where fish can injure themselves on the turbine blades, and they are also exposed to strongly fluctuating pressure. At Bannwil hydropower plant, the project partners used high-tech sensors, monitoring technology and various models to study the passage of downstream migrating fish through the turbines and over the weir.

It turned out that the passage at hydropower plants can be hazardous to fish not only because of the turbines: When descending over weirs, they can also be injured by the strong currents in the stilling basin or lose their orientation, making them easy prey for predators. "Our results can help, for example, to develop fish-compatible turbines, to adapt power plant operations during periods of fish migration and to improve weir design for safe fish passage" explains Ismail Albayrak, senior scientist and project manager at VAW.

VAW researchers also conducted extensive hydraulic testing with fish guidance racks in the laboratory to better understand the behavior of local fish species in turbulent currents. They then used the results to develop an innovative protection and guidance system for downstream migrating fish called the curved-bar rack bypass system (CBR-BS).

The core of the CBR-BS is a vertical bar rack with specially shaped bars; these create strong local eddies that steer fish away from the bar rack and towards a bypass. In this way, the CBR-BS is able to guide a variety of fish species of different sizes safely past the turbine. The bypass system is also designed so that the plant's operations are only slightly affected.

FIThydro was officially completed at the end of 2020 and an online final international conference will take place on 17-18 March, However, the researchers stress that there is still a lack of tried and tested solutions for fish protection and guidance in Europe, in particular at large hydropower plants. It's clear to Boes and Albayrak that they must continue with their research. "The next logical step is a pilot and demonstration hydropower plant, where we want to test a CBR-BS under real conditions," says the professor of hydraulic engineering.

Openly accessible tools and wiki

In addition to numerous case studies on hydropower plants across Europe, the FIThydro consortium has also developed new evaluation methods and tools that are now openly available. These include a fish population hazard index, simulations of fish migration and a decision support tool for planning projects. A wiki website also provides detailed insights into the results of the case studies and existing and recently developed solutions for fish bypasses.

More information: FIThydro decision support tool: www.dss.fithydro.wb.bgu.tum.de/home/ui

Fish protection and fish guidance at water intakes using innovative curved-bar rack bypass systems doi.org/10.3929/ethz-b-000439606

Fish protection and guidance at water intakes with horizontal bar rack bypass systems doi.org/10.3929/ethz-b-000455545

Provided by ETH Zurich