Executive Summary

D3.1 Guidelines for mortality modelling

Many rivers in Europe are highly modified to serve different purposes such as irrigation, flood control, navigation and energy production. These man-made modifications include structures such as locks, weirs and power plants which influence the migration of fish in both upstream and downstream directions. This requires an assessment of fish passage at weirs and hydropower plants. One aspect is the fish passage through the turbine at hydropower installations, which can be related to injury and mortality, caused by several damage mechanisms.

The guidelines in this deliverable present both basic and more detailed methods to quantitatively asses the fish passage through a hydropower turbine. The methods consider boundary conditions of the hydropower plant, as well as biological attributes and behaviour of the relevant fish species, which influence the survival statistics significantly. Adequate mortality modelling requires a detailed understanding of underlying processes in order to develop suitable mitigation measures.

The work related to this deliverable involved ten partners from five countries across Europe (IST, Voith Hydro, TUM, TUT, IGB, BKW, ETH, INBO, SAVASA, ITAGRA). Within the scope of the FIThydro project, the work focused on Kaplan turbines and particular European setups. Work included the deployment of BDS (Barotrauma Detection System) sensors at three test cases, live fish experiments in a laboratory facility, theoretical work on mortality modelling as well as comprehensive CFD (Computational Fluid Dynamics) simulations of three test case turbines for various operating conditions applying the Biological Performance Assessment (BioPA) approach. The good agreement of experimental pressure measurements by BDS sensors and the calculated nadir pressures using a numerical model of the hydraulic turbine confirm the suitability of both approaches for clarification of pressure regimes, which fish experience during turbine passage. Comprehensive information on the BDS system will be provided in a separate deliverable.

Research work on mortality models led to a generalized modelling approach, which consolidates different existing approaches and enables a wider range of application. Therefor required approximations for flow conditions close to the turbine runner were derived and compared to the results from CFD to assess their suitability and accuracy. These relations provide a valuable foundation for simple mortality assessment with broad applicability. This enables an improved ecological assessment of hydropower. Modelling guidelines have been developed, to include state-of-the-art research results to practical application. The live fish experiments could demonstrate the impact of different parameters on fish damage and confirm the influence of fish behavioural aspects on mortality rates during turbine passage. Due to the high complexity and various interactions, a final clarification of questions on actual fish behaviour requires further research beyond the scope of the FIThydro project. The revealed relations of fish pathways and mortality as well as the demonstrated possibilities to influence those provide promising results for the Induced Drift Application (IDA), which will be treated in detail in an upcoming deliverable.

The CFD based fish passage analysis was performed using the BioPA modelling approach for representative European hydropower plants with a power output from 35 kW up to 10 MW. The analysis provided comprehensive and detailed information on hydraulic stresses on fish during turbine passage. Parameter variations of fish behavioural aspects and characteristics showed the sensitivity of the impact on the fish during turbine passage and helped to set the correct focus for future investigations. The generation of fish passage hill-charts for typical stressor

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variables enables an improved turbine operation in relation to fish passage. Different physical impacts can be judged individually and a temporary adaption of operation can be implemented. The exemplary application for a range of typical European machines provides valuable knowledge for further application at hydropower plants. The developed SMTDs are of highest interest for future development of fishfriendly turbine design and operational schemes for improved fish passage at hydropower plants.

The contemporary research on fish passage assessment still leaves a number of remaining knowledge gaps. While physical stress on fish during turbine passage can be assessed by the demonstrated techniques, the biological response to given stress levels needs to be quantified in order to deduce accurate mortality predictions. A comprehensive database is needed, especially accounting for relevant European species. The biological response data can be derived from respective experimental work. In addition to the fish susceptibility to single stressors, an approach to account for multiple stressors at a time needs to be developed for enhanced mortality modelling. A second main topic of fish passage modelling which has been identified is the influence of fish behaviour on mortality rates. The present work gives insight into the magnitude of different influences and demonstrated that fish behaviour can have significant impact. Actual fish behaviour during turbine passage remains widely unknown and has to be clarified by respective experimental work. The improved understanding of fish damage processes also enables the development of efficient mitigation measures.

Full deliverable download

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