***Passage solutions for salmonids and other fish species**:* *Stress-testing today's environmental measures for an uncertain future*

Workshop Report, Hydropower R&D Days 2026

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Is today's knowledge and practice sufficient to guide the design of fish passage solutions that ensure long-term sustainable fish populations and maintain ecological function in future regulated rivers?

The Hydropower R&D Days workshop on 11 March 2026 examined whether current fish passage solutions and environmental measures in regulated rivers are sufficient to ensure long-term ecological function and sustainable fish populations under uncertainty, including climate change and trade-offs with hydropower production. The session was chaired by Johan Watz from Karlstad University and featured an expert panel comprising Daniel Nyqvist (Researcher at Swedish University of Agricultural Sciences), Lovisa Lind Eirell (Technical Judge at the Environmental Court, Östersund), David Aldvén (Fisheries Biologist and Program Manager at Vattenfall R&D), Anna Hagelin (Project Leader at the County Administrative Board of Västra Götaland), and Olle Calles (Professor at Karlstad University). The workshop had approximately fifty participants attending, including pre-registered individuals and additional attendees admitted on the day. Participants came from Sweden, Norway, and Finland and represented a range of sectors, including the hydropower industry, fisheries technology companies, consultancy firms, NGOs, county administrative boards, the Environmental Court, universities, and research institutes.

The primary objective of the workshop was to critically examine whether current scientific knowledge, policy instruments, and practical measures in regulated rivers are sufficient to ensure long-term sustainable fish populations and maintain ecological function, particularly under the uncertainties posed by climate change and the balance between ecological protection and hydropower production. The session sought to explore whether existing fish passage solutions are fit for purpose over the long term and to stimulate reflection on gaps and opportunities for adaptive management.

The workshop followed a highly interactive format designed to promote structured dialogue between the audience and the expert panel (Table 1). Each statement was presented on the screen with context, and the audience responded using Mentimeter by indicating whether they leaned toward “true” or “false.” The expert panel responded simultaneously using individual response cards. After audience responses were revealed, the moderator guided discussion exploring differences and similarities between panel and audience perspectives, highlighting uncertainties, and probing practical implications for management. This format encouraged critical engagement and direct exchange of perspectives, and the audience actively asked questions throughout the session, demonstrating strong interest in the topics discussed.

The statements addressed during the workshop were clustered into four thematic areas. The first cluster focused on the sufficiency of current knowledge and the effectiveness of fish passage solutions. The panel largely agreed that existing knowledge is sufficient to design effective fishways for most species and emphasized that high passage efficiency at the individual level does not automatically translate into population-level benefits. The audience responses were more divided, prompting discussion about, for example, differences between upstream and downstream passage and life-stage-specific considerations.

The second cluster examined long-term functionality of environmental measures and trade-offs with hydropower production. While the panel expressed caution regarding the assumption that fish passage solutions implemented today will function as intended in 50 years, the audience was somewhat more optimistic. Discussions explored seasonal and interannual variation, as well as the expected impacts of climate change on river flow patterns. Panel and audience perspectives also diverged on whether all effective environmental measures require reductions in electricity production, with panelists emphasizing the potential role of habitat restoration and integrated flow management. The emphasis on fish passages versus other measures such as habitat restoration also led to discussion on balancing priorities for long-term ecological outcomes.

The third cluster addressed monitoring and adaptive management. Both the audience and panel strongly agreed that environmental measures are frequently implemented without sufficient follow-up, leading to uncertainty about their effectiveness. This consensus sparked discussion on how inadequate monitoring can reduce cost-effectiveness. Similarly, the lack of scientific knowledge being used as a reason to delay decision-making rather than promote adaptive management elicited engagement from both panel and audience, highlighting the need for learning-based approaches in regulated rivers.

The fourth and final cluster examined planning, technology, and policy frameworks. Both panel and audience generally disagreed with statements assuming that the National Plan for Hydropower Permit Reviews (NAP) will be completed by 2045. Statements concerning the potential of artificial intelligence to resolve conflicts between ecological protection and electricity production prompted cautious discussion from the panel, who emphasized that AI can support planning but cannot replace ecological assessment or policy guidance. Finally, there was broad agreement that current ecological status classifications under the Water

Framework Directive are insufficient to ensure long-term biodiversity conservation, though nuances were discussed regarding the limitations of existing frameworks.

The workshop successfully brought together experts, practitioners, and stakeholders from diverse sectors to engage in in-depth discussion on fish passage solutions and environmental measures in regulated rivers. By comparing panel expertise with audience perspectives, exploring uncertainties, and debating trade-offs, the session provided a valuable forum for knowledge exchange and critical reflection. The interactive format fostered dialogue, clarified differing viewpoints, and highlighted both areas of consensus and key challenges, demonstrating the importance of collaborative discussion for informing future management of river ecosystems.

Table 1. Results from the real-time opinion polling with structured discussion by an expert panel and the audience of the workshop session.

Statement	Audience Yes	Audience No	Panel Yes	Panel No	Key Discussion Points
1. Current scientific knowledge of fish passages is sufficient to design effective fishways for most species	16	26	1	4	Differences between upstream vs downstream passages, life-stage-specific considerations, meaning of "most" species.
2. Fish passages that demonstrate high passage efficiency at the individual level will undoubtedly produce positive effects at the population level	8	35	0	5	Population-level effects not guaranteed; importance of habitat connectivity.
3. Fish passage solutions implemented today will function as intended in 50 years even though climate change will alter flow regimes	25	17	4	1	Seasonal vs interannual variation, altered flow patterns due to climate change.
4. All ecologically effective environmental measures in regulated rivers require some reduction in electricity production	7	32	1	4	Role of habitat restoration as alternative or complement.
5. Emphasis on fish passages has come at the expense of measures addressing flow and habitat restoration	22	14	2	3	Balancing fish passage with flow and habitat measures.
6. Environmental measures are frequently implemented without sufficient monitoring, leaving uncertainty about their function	28	10	5	0	Consensus on need for monitoring; discussion of inefficiency of unmonitored measures.
7. Lack of scientific knowledge is more often used to delay decision-making than to advance adaptive, learning-based management	24	13	2	2	Delays caused by knowledge gaps.
8. The National Plan for Hydropower Permit Reviews (NAP) will be completed by 2045	6	31	1	4	Risk of compounded delays; importance of realistic planning timelines.
9. By enhancing the planning of environmental measures, AI will help to resolve the fundamental conflict between ecological protection and electricity	10	26	1	3	AI is a supporting tool, not a solution.
10. Current ecological status classification under the Water Framework Directive is adequate to support the long-term conservation of biodiversity	6	27	2	2	Limitations and streangths of current WFD classifications.