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Fischnetz: Assessing outcomes and impacts of a project at the interface of science and public policy

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ABSTRACT

Long-term reviews are necessary to appreciate the full outcomes and impacts of the scientific, societal and policy perspectives of transdisciplinary projects. Here, thirteen years after its completion, we assess the significance of a five-year (1999–2004) Swiss research project. The *Fischnetz* project aimed to identify the causes of fish catch decline and propose remedial measures. Engineers and scientists from different disciplines collaborated with practitioners and policy makers to approach this real-world problem and develop and implement policy interventions. *Fischnetz* proved to be an exemplarily successful case of how transgressive and socially robust research can be conducted and result in high-quality scientific outputs and policy impacts. As a result of *Fischnetz*, The Swiss Federal Water Protection Act was fully revised, two by-laws were changed, and several parliamentary interventions were launched. *Fischnetz* produced 68 scientific ISI-papers with higher than average citations. In this report, the project setup and its overall outcomes were analysed via a Mode-2 knowledge production approach.

1. Introduction

The project *Netzwerk Fischrückgang Schweiz* (project on fish catch decline in Switzerland), abbreviated '*Fischnetz*', was conducted between 1999 and 2004. Considerable decreases in inland fish catches of up to 60% since the 1980s were recorded by anglers. These declines appeared geographically widespread and affected various species, including brown trout (Fischnetz, 2004a). Impairments to the health of the wild brown trout population were also detected, most evidently downstream of sewage treatment plants (Burkhardt-Holm et al., 2008). A nationwide effort was initiated to elucidate the reasons for these phenomena, identify the key causative factors and develop remedial measures. The aim of *Fischnetz* was to tackle this challenge and the project demanded an inter- and transdisciplinary research approach. The specific objectives were: (I) collection, synthesis and evaluation of data on fish catch, fish health and population abundance for the last 20 years; (II) identification of the most important factors responsible for catch decline and impaired health status, and initiation of new research activities to fill the identified knowledge gaps; and (III) proposal of remedial measures.

Reporting and evaluation of the success of transdisciplinary research projects in a systematic, structured manner has been repeatedly emphasized (e.g. Buxton, 2011; Schmid et al., 2016; Krainer and Winiwarter, 2016), and aligns with the current trend that public research investment ought to derive benefits for society (European Commission, 2010). Long-term review is crucial to evaluate the impact of transdisciplinary projects. The optimal time for review is a function of the research results, intended impacts, field of practice where impacts will occur, and tangibility of the outcomes (Kaufmann-Hayoz et al., 2016). In particular, societal impacts are not imminent and take time to become apparent (Bornmann, 2013). Two to 17 years after the end of a project have been reported as good time-points for evaluation (e.g. Molas-Gallart et al., 2000; Buxton, 2011; Balvanera et al., 2017). Impacts may not yet be clear after a short time, yet waiting too long may blur causality and attribution (Bornmann, 2013). The results of *Fischnetz* were thought to have immediate and long-term policy relevance. As a consequence, thirteen years after the end of the project seemed an appropriate time to obtain a full picture of the outputs, impacts and outcomes, without interfering with causality.

Several approaches have been developed to conduct and evaluate projects in which scientists, policy-makers and other actors cooperate directly, and where a plurality of knowledge sources is combined to address real-world issues. One discipline alone is usually insufficient to find solutions to the complex problems in our modern world. Increasingly, academia alone cannot provide answers. Inputs from a combination of disciplines and societal stakeholders are necessary for

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joint problem solving. While traditional knowledge production (Mode-1 knowledge production) occurs within a disciplinary, primarily cognitive context, Mode-2 knowledge production emerges in broader, transdisciplinary contexts (Gibbons and Nowotny, 2001;Gibbons et al., 1994). The various 'new knowledge production approaches' include 'joint knowledge production' (e.g. Hegger and Dieperink, 2014), 'knowledge co-production' (Armitage et al., 2011) and 'socio-ecological research' (Lang et al., 2012), among other concepts. For this evaluation, we decided to follow the Mode-2 knowledge production concept, which provides a blueprint for the set-up of research programs that promise societal, economic and policy impacts as ultimate goals, with high levels of uncertainty and complex causal paths between inputs and impacts. The transdisciplinary *Fischnetz* project was characterized by a combination of scientific and societal aspects, which falls under the remit of Mode-2 knowledge production.

Here, we initially describe the definition and inclusive development of the scientific program, the process of integrating all relevant societal stakeholders as partners and funders, and review the organization and anchoring of the project in relevant stakeholder circles. Secondly, we compile and assess the scholarly and societal outcomes the project had and continues to have on science, policy and society. Thirdly, we explore the policy impact, or in other words, what really changed as a result of this research within the context of a broad discussion of the different relevant societal participants.

2. Background of the *Fischnetz* project

This project must be understood in its political and historical context. Catch declines and impairments to fish health were observed in many other countries towards the end of the last century (Cowx, 2015). Fish are generally viewed as an indicator of water quality, and a decline in fish numbers triggers emotional doubts regarding water quality. Moreover, the book "*Our Stolen Future*" (Colburn et al., 1996), along with media reports about the presence of chemicals with endocrine-disrupting activities in rivers and lakes, fuelled doubts on water safety and created strong public pressure for action.

The level of public interest in this project was high, since approximately 240,000 individuals, equivalent to 6% of the Swiss population between 15 and 74-years-old, practice angling at least once a year (Burkhardt-Holm, 2008a). Catch decreases have consequences on angler satisfaction, as well as the sale of angling licenses that contribute to cantonal incomes. Between 1980 and 2000, the sale of angling permits for running water systems decreased by 23 percent and combined permits (rivers and lakes), by 46 percent (Fischnetz, 2004a). Public and financial pressure were strong drivers for inclusive development of a research program based on twelve hypotheses. The partners, federal and cantonal authorities, anglers and scientists agreed to the program in the autumn of 1998 (Supporting information, Fig. S1).

Fischnetz was organized with a steering committee (board) and project management (executive). Two of the six steering committee members were members of the cantonal governing council responsible for finance, one of whom chaired all cantonal finance councillors in Switzerland. The other four members were the director of the Swiss Federal Office for the Environment (FOEN); a representative of the Swiss Association of Chemical Industries (SGCI); the president of the Swiss Fisheries Association (SFV), an NGO; and as chair of the steering committee, the director of the EAWAG, the Swiss Research Institute for Aquatic Science and Technology (a co-author of this paper). The steering committee set the priorities, monitored advancement and success, and was responsible for implementing the relevant policy measures.

The *Fischnetz* steering committee was instrumental in obtaining financial support from all 26 cantons and the principality of Liechtenstein. For the first time in Swiss scientific history, all cantonal political entities and the principality of Liechtenstein contributed cash funds to a scientific project. Right at the start, the SGCI committed the necessary financial means to investigate the role of chemicals in fish health impairment. The FOEN and EAWAG acted as leading institutions and ensured project realization and management, and contributed financing. The SFV supported with anglers volunteering for field work. The contributions of these partners represented the core financing of *Fischnetz*, totalling 4.8 million Swiss Francs for the five-year period (Supporting information, Fig. S2A). Subsequently, additional topic-specific support was provided by the Swiss National Science Foundation (SNSF) for a program on endocrine disruption, by universities for their own collaborating groups, and from a variety of other funds. External third-party funding contributed considerably to *Fischnetz*; 47 of the 77 sub-projects were externally financed (Supporting information, Fig. S2B).

The project management comprised twelve individuals with expertise in different disciplines, i.e. fisheries science, environmental chemistry, ecotoxicology, physiology, fish disease, population biology, limnology, hydrology and climate change. These individuals also represented the various stakeholders, federal and cantonal authorities, chemical industry, Swiss fisheries associations and scientific communities (the head of the project management team is the lead author of this paper). The team's priority tasks were to identify knowledge gaps, coordinate the different sub-projects, reduce overlaps, profit from synergies arising to achieve project objectives, and synthesize and communicate results.

From the outset, other projects already running in Switzerland were invited to join as sub-projects, provided they were contributing to at least one of the objectives of *Fischnetz*. Further prerequisites were to allow access to raw data and willingness to participate in productive scientific discussions and actively collaborate with *Fischnetz*. Prior to initiation of the project, the relevant literature was analysed, the results of former and recently completed projects in Switzerland and adjoining regions were evaluated, and national and international scientists were invited for expert hearings (Fischnetz, 2004b). With this information at hand, sub-projects for further research were defined and prioritized (Burkhardt-Holm, 2008a). Most sub-projects were field studies, monitoring projects and synthesis work. To a large extent, the synthesis work was financed by the core *Fischnetz* funding (Supporting information, Fig. S2B). More than 400 people were directly involved in *Fischnetz* (Fischnetz, 2004b).

The initially defined network of hypotheses (Supporting information, Fig. S1) proved beneficial for identifying important causes and intermediate effects. Several studies helped disprove some hypotheses (Burkhardt-Holm et al., 2005). To combine data from the numerous sub-projects creating heterogeneous knowledge and provide more general conclusions, a Bayesian probability network model and weight-of-evidence-analysis were applied (Borsuk et al., 2006; Burkhardt-Holm, 2008b). The major factors leading to catch decline were reduced fishing and a reduction in fish populations. The causes of population decline were primarily impaired health as a consequence of proliferating kidney disease (PKD), poor water quality and deteriorating habitats (Burkhardt-Holm et al., 2005). The increased incidence of PKD was the result of a changing annual temperature regime in rivers triggered by climate change (overall increase in water temperatures, primarily due to earlier spring; Hari et al., 2006). As a consequence, the ideal thermal habitat for brown trout had risen in altitude by 130 m (Hari et al., 2006). Upstream escape was difficult to impossible for fish due to insurmountable artificial obstacles mainly built for flood mitigation.

3. Methods, their application for quantifying scientific output, and societal and policy impact

3.1. Methods

3.1.1. Web search

Web searches were used to identify the products and performance of