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Decline of brown trout (*Salmo trutta*) in Switzerland – How to assess potential causes in a multi-factorial cause–effect relationship

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ABSTRACT

A considerable decline in fish catch in Switzerland triggered a 5-year project (Fischnetz) to investigate potential causes. The results of many field and laboratory studies, together with literature and historical data, indicated a need for a concise synthesis of the results. Therefore, Bayesian probability network (BPN) and weight-of-evidence (WOE) approaches were applied. Here, these both approaches are compared and evaluated. In addition, the potential reasons for the (mis)match in the two approaches were evaluated. In both studies, proliferative kidney disease (PKD), caused by a parasite, and the clinical outbreak supported by various factors, was a very probable single parameter. WOE assessed habitat and streambed quality as likely for contributing to impaired health, recruitment and abundance at single sites only, but this parameter was assessed to be the most important and ubiquitous stressor in the BPN. Mismatches suggested that these factors were either not considered or not equally assessed by the different models, which is due to different endpoints, incomplete data sets and different handling of these various data sets by the applied synthesis approaches.

Fish catch declined by approximately 50% in Swiss rivers since the 1980s (Burkhardt-Holm et al., 2005). Additionally, impaired health status, namely lesions at gills, liver, skin and kidney, as well as parasitic infestations were observed repeatedly (Bernet et al., 2004; Schmidt-Posthaus et al., 2001). To document the situation and assess potential causes, a project named "Fischnetz" was conducted. It formulated 12 hypotheses on the potential causes (Table 1). Research questions for all hypotheses were posed and addressed in laboratory and field projects using a multitude of biomarkers (Burkhardt-Holm et al., 2005). For example, to document the impaired health status, we measured condition factor, hepatosomatic index, histological liver index (Bernet et al., 1999), 7-ethoxyresorufin-*O*-deethylase (EROD) activity and PKD infection (Faller et al., 2003; Burkhardt-Holm and Scheurer, 2007; Wahli et al., 2007).

To put all results in context, an integrative synthesis was needed to value the single results (Burkhardt-Holm, 2007). Therefore, a Bayesian probability network model (BPN) and a weight-of-evidence analysis (WOE) were applied. The BPN was based on a dynamic age-structured population life-cycle-model, characterized by population parameters such as growth, survival, and reproductive rates. These parameters were then linked to external indicators of habitat quality and anthropogenic influences. The identified relationships were based on any information, including elicited judgements of experts when experimental data were missing. A measure of causal strength was based on a comparison of predicted brown trout abundance under both actual and hypothetical reference conditions. Not included in this model were parameters for which not sufficient quantitative data were available, such as food availability or micro pollutants (Borsuk et al., 2005).

The WOE approach, a semi-quantitative method, is based on epidemiological health criteria, considering the exposure situation, the correlation between causes and effects, the specificity of effects, experimental evidence for cause–effect relations and amelioration due to removal of agents (Burkhardt-Holm and Scheurer, 2007). As 'reference site', necessary to answer the question on correlation, the headwater sites of the river basins were taken. Factors such as angling and stocking, were not considered because spatial resolution of this data was not sufficiently detailed to differentiate between individual sites at the study locations. With WOE, the process of assessment is made more transparent, systematic, logical, and it facilitates communication. It allows assessment of factors that are more or less likely when quantitative data are limited, but it is not definitive in terms of ascribing causation, since it is post-hoc.

The aim of this paper was to critically compare these different approaches which were used to analyse complex data sets in order to identify detrimental causes for decline of fish catch. Both approaches were made in the context of the same project Fischnetz, they tried to answer the same 'final' question ('what are the causes of the decline in fish catch, abundance and health status of brown

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Table 1
The 12 hypotheses of the project ‘‘Fischnetz” comprising the potential causes for the fish catch decline in Switzerland

(1)	The decline of fish catches are due to more than one factor, very probable, each having a different regional importance
(2)	The fish population is affected by reproductive failure of adult fish
(3)	or from reduced recruitment of young life stages
(4)	The health and fitness of the fish are impaired
(5)	Chemical pollution (both nutrients and micro pollutants) is causing harmful effects
(6)	Poor morphological quality and longitudinal connectivity of rivers affect fish survival and recruitment
(7)	The relative amount of fine sediments has increased and led to sediment clogging, which reduces spawning success and disturbs the embryonic development of brown trout
(8)	The amount or quality of food is insufficient
(9)	Fisheries management, i.e. stocking and angler behaviour are causing the declining fish catches
(10)	Excessive removals of fish by birds is responsible for apparent declines
(11)	Water temperature has changed to the disadvantage of the fish, especially trout
(12)	High floods in winter and corresponding sediment transport have changed detrimentally

trout’), used data of the same four river basins, and agreed in the general classification of factors, thus, the prerequisites for a comparison are given. In addition, the present study investigated which results of these two approaches are in accordance, and which mismatch. In addition, potential reasons for any (mis)matches are discussed.

In both approaches, proliferative kidney disease (PKD) was identified as a very likely single parameter. This match was due to the fact that the data base for assessing this factor was extensive (Wahli et al., 2007), a statistical significance between occurrence of PKD and young-of-year abundance was shown (Schager et al., 2007), and the relation to a specific life stage was unambiguous.

Both approaches further agree in (I) the relative impact of the different stressors depending on the conditions of the specific locations and (II) at most sites more than one factor must be acting jointly to cause the observed decline in brown trout abundance and catch. According to the WOE assessments, elevated levels of nitrogen compounds posed a potential serious risk at some sites, in particular those downstream of sewage treatment plants, whereas BPN considered this factor more ambiguous, due to the fact that the effects were exerted prior to the end of density dependence at the end of the first summer. The WOE approach highlighted habitat and streambed quality (considering depth, width, % riffles, longitudinal connectivity, riverbed siltation, and shade) as likely contributing factors to impaired health, recruitment and abundance at single sites only. The BPN approach indicated the factors as most important and ubiquitous stressors at nearly all sites, potentially responsible for reductions of over 50% in nine of the 12 populations.

It can be suggested that differences in the assessment of importance of the proposed causes are due to the following aspects: The BPN related the used variables according to their relevance for life stages. The BPN had a time component due to a simulation of 120 years, which made a need for historical data comprehensible. However, not considered were parameters for which only singular data were available. In contrast, the WOE answered questions only according to the epidemiological criteria and considered every parameter solely. It used intermediate factors instead of sub-models, which made it flexible to relate primary factors to intermediate factors when they were not controlled directly by the primary causes. All data sets were related either to fish health, reproduction success or population abundance –and not a priori regarding life stage specificity.

In conclusion, depending on the databases used, selection of reference status, and weighing the importance of aspects such as time and life stages and intermediate factors, different outcome in integrative approaches have to be expected. However, matches in results confirm the importance of the proposed factors. It is suggested to select the approach according to the kind of question asked: WOE is a retrospective ecological risk assessment judging on the likelihood of potential causal factors. BPN can be used to estimate the relative importance of factors (with sufficiently large data sets) by comparing various model scenarios. Both approaches facilitate management decisions.

References

Bernet, D., Schmidt, H., Meier, W., Burkhardt-Holm, P., Wahli, T., 1999. Journal of Fish Diseases 22, 25–34.

Bernet, D., Schmidt-Posthaus, H., Wahli, T., Burkhardt-Holm, P., 2004. Hydrobiologia 524, 53–66.

Borsuk, M.E., Reichert, P., Peter, A., Schager, E., Burkhardt-Holm, P., 2005. Ecological Modelling 192, 224–244.

Burkhardt-Holm, P., 2007. In: Hirsch Hadorn, G., et al. (Eds.), Handbook of Transdisciplinary Research. Springer.

Burkhardt-Holm, P., Scheurer, K., 2007. Aquatic Sciences 69, 51–70.

Burkhardt-Holm, P., Giger, W., Güttinger, H., Peter, A., Scheurer, K., Suter, M.J.-F., et al., 2005. Environmental Science and Technology 39, 441A–447A.

Faller, P., Kobler, B., Peter, A., Sumpter, J.P., Burkhardt-Holm, P., 2003. Environmental Toxicology and Chemistry 22, 2063–2072.

Schager, E., Peter, A., Burkhardt-Holm, P., 2007. Aquatic Sciences 69, 41–50.

Schmidt-Posthaus, H., Bernet, D., Wahli, T., Burkhardt-Holm, P., 2001. Disease of Aquatic Organisms 44, 161–170.

Wahli, T., Bernet, D., Steiner, P.A., Schmidt-Posthaus, H., 2007. Aquatic Sciences 69, 3–10.