Fish – Indicators and Winners

Over the last 10 years, fish yields in Switzerland have dropped dramatically. Investigations on the health of fish have often revealed abnormalities. The project "Network Fish Decline in Switzerland", or "Fishnet" for short, is investigating the causes of the decline and will develop proposals for remedial action over the next few years.

Switzerland's streams are intensively managed. Stream management and stream use is always preceded by an evaluation process, optimizing the management practices. Fish are important in two ways: as a tool for evaluating the health of a stream and as an economic factor.

Managing Streams

Some 6% of Switzerland's population consider themselves to be fishermen. In 1997, approximately 240,000 people between the ages of 15 and 74 picked up their fishing rods at least once. On average, a fisherman spends 3500 Francs per year on his or her hobby. Of the total of 216 Million Francs spent on fishing, 12 Million Francs find their way into the coffers of the cantons from the purchase of fishing permits [1]. Declining fish populations and compromised health of the fish, however, suggest revenue problems in the near future.

Evaluating Streams

Fish are extremely important indicators of stream quality. This is reflected, in part, in the Swiss Modular Concept (see article of A. Peters, p. 7) in which one entire module is dedicated to fish. Evaluation criteria include population sizes, fish health, and species diversity. Disturbances of habitat result in a reduction of diversity. Today, 42 of the original 54 domestic fish species are acutely endangered in Switzerland.

Assessment of population sizes is a major endeavor and requires extensive experience in fisheries. Population data are available only sporadically, although most cantons have information on the numbers of fish that are caught. Information compiled by the SAEFL shows a dramatic decline in these numbers, at least for trout, the most heavily fished species. On average, the decline in Switzerland is 42% over the past 10 years [2].

There are several very recent studies on fish health which have reported significant deviations from the norm. What has made headlines worldwide are reports that hormonally-active chemicals cause abnormal sexual development in fish [3].

The project "Network Fish Decline in Switzerland", brief "Fishnet", was initiated in December 1998 in response to these kinds of problems. The project was conceived by EAWAG and SAEFL, and currently receives additional support from the Swiss Fisheries Association, the cantons and the chemical industry. It is scheduled to operate over a period of 3–5 years. Early recognition of risk factors for fish health, population declines and related impacts on streams are some of the main goals of the project.

What is the project Fishnet trying to accomplish?

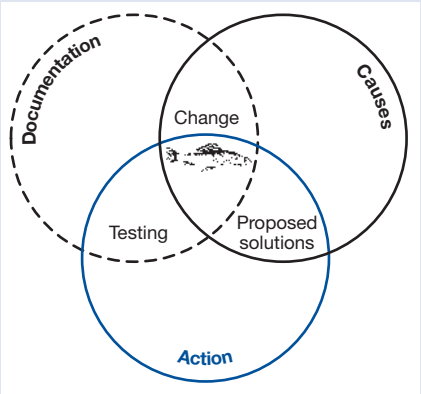

Fig. 1: Goals of the project Fishnet.

The project is targeting three levels (Fig. 1):

- Documentation: Changes in fisheries' yields and populations as well as the development of fish health in Swiss streams and lakes over the last 30 years (comparison between then and now).
- Analysis of causes: Definition of groups of causes and identification of the most important causes for the observed changes.
- Response: Development of options for remedial action and communication tools appropriate for the target audience.

A Comparison to the Debate on Forest Decline

The project Fishnet faces a number of challenges. The general character of the problems is reminiscent of the ones encountered during the debate on forest decline in the 1980s. The following three characteristics are shared by both issues:

1. Both the public and the scientific community had high expectations for the research on forest decline: the causes were expected to be identified very quickly with the formulation of practical solutions shortly thereafter. Fishnet has induced similar expectations. In the case of forest decline, the debate was often emotional and led to controversies that still reverberate today. This created divisions among scientists and between scientists and citizens. We know that public relations are very important on this type of topic, but one has to proceed with great care; all affected groups should be included in the process, and conflicts should be acknowledged and communicated to all participants as soon as possible.
2. Both problems are similar in that the systems are extremely complex and that there is spatial and temporal separation of the

causes and effects. Clearly identifying causes is, therefore, rather difficult. In the case of forest decline, the discussion focused on the effects of atmospheric pollution fairly early on. Fishnet is intentionally trying to remain open to the discussion of as many potential causes as possible. When designing such projects, one has to keep in mind the following statement: "We find cause-effect relationships where we invest money in research; we find no such relationships where we do not invest money" (P. Brang, Swiss Federal Research Institute WSL, expert discussion Fishnet, 12 April 2000). Coordination of the research effort and synthesis of the results into generally understandable conclusions are essential. Research on forest decline has taught us that the effect of pollution on trees can vary with location. We assume that this also applies to problems related to fisheries and fully expect that regional conditions are an important factor in determining fish declines.

3. Because of the high level of complexity, the prediction of trends is very difficult, both for a scenario without any change in current practices and for one with human intervention and remedial action. It is extremely difficult to convey this type of dilemma to the public; caution or restraint are often misinterpreted. Measures taken to stop forest decline turned out to be successful (e.g., the reduction of atmospheric pollutants by requiring catalysts on motor vehicles), but their scientific justification was considered questionable.

How Will Fishnet Proceed?

Fishnet sees itself not only as a network of activities, research and ideas, but also as a network of people: those causing the problems, those bearing the consequences, and those who are involved in the research. This network structure allows us to recognize gaps in our knowledge more readily and work towards our goals more methodically. Double-tracks can be avoided, while synergisms can be recognized and fostered early on. Standardized methods will be essential in assuring comparability of results. Relevant questions will be investigated in sub-projects. The sub-projects will report to the project leader who, in turn, will distribute results from the overall project to the individual sub-projects. This parallel attack on several fronts will allow us to broaden and deepen our approach without sacrificing time.

In regular meetings of the sub-project leaders, results will be discussed and methodologies updated. New or modified research directions will be considered. It will be particularly important to maintain a complete collection of documents from all of the sub-projects so that anyone within the project can efficiently access information long before it is published.

What Will Fishnet Do?

Twelve working hypotheses form the core of the project. Hypothesis 1, an "integrative" hypothesis, is based on the assumption that there are multiple effects, any or all of which can vary over time and with habitat, fish species, and sex. The various factors or effects may be additive, cancel each other out, or even enhance one another. Hypotheses 2–5 deal with effects caused by pollutants: disruption of the reproductive cycle, increased mortality of young fish, malfunc-

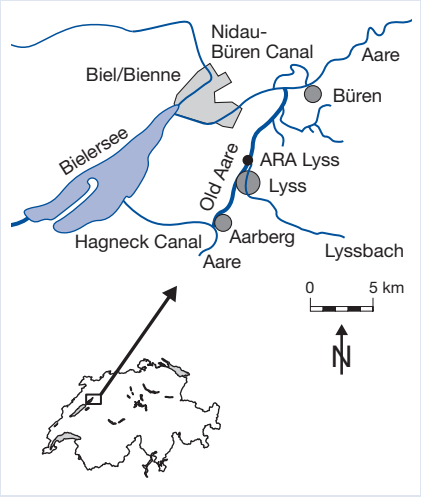

Fig. 2: The course of the Old Aare, Canton Berne [4].

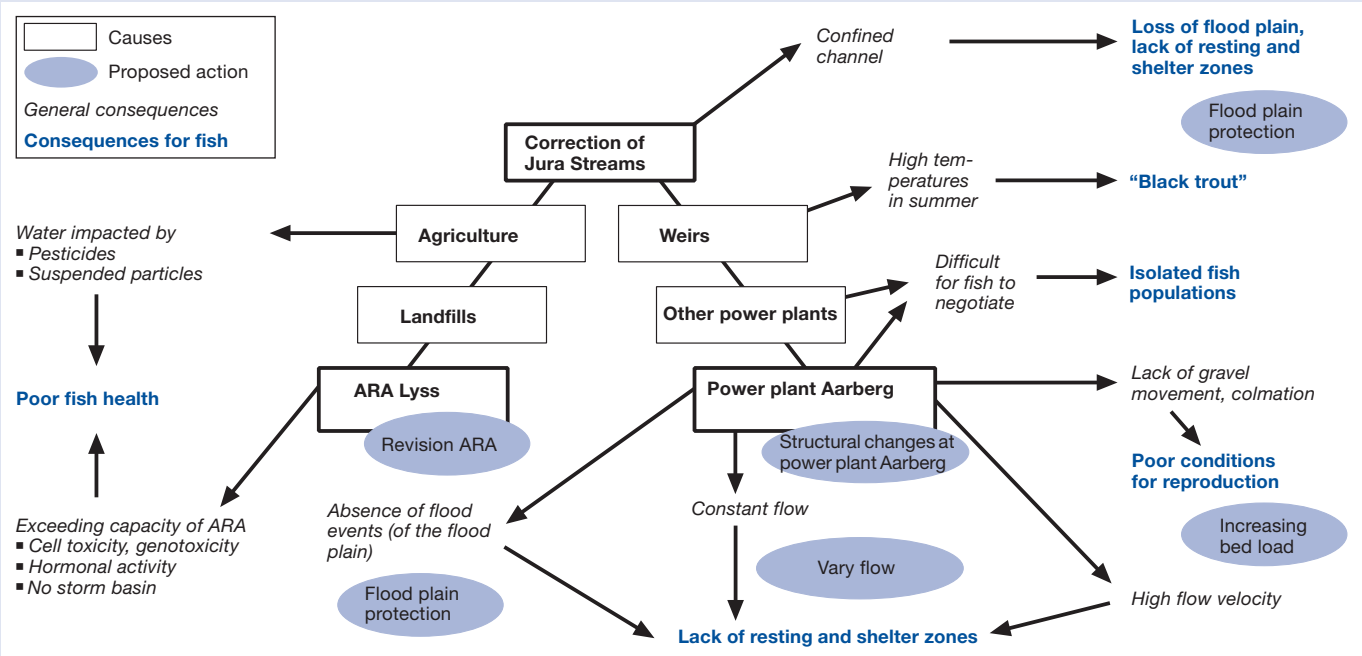

Fig. 3: Analysis of the situation in the Old Aare.

tions in organs, or impacts on the immune system after infestation with parasites or diseases. Hypotheses 6–10 focus on various other possible causes: inadequate spatial variability within a habitat, impact on reproduction by colmation (increased concentration of suspended particles in the pore volumes of the stream bed), decreased food supplies, introduction of fish species inappropriate for a particular habitat, increased utilization by fishermen, and imbalance between fishing pressure, natural predation, and population growth. Hypotheses 11 and 12 relate specifically to trout streams where climatic changes can alter the temperature and flow regimes. The hypotheses lead to primary research questions which are then assigned to subprojects. Currently, 25 sub-projects are in progress, and there is informal contact with an additional 12 projects. Fishnet also keeps in close contact with projects and institutions abroad.

A Synthesis Project: The Old Aare in Canton Berne

Repeated fish kills and the occurrence of visible fish diseases has led to a massive fish decline in the Old Aare in Canton Berne. In response, the Council of the Canton Berne has ordered an extensive scientific investigation (Fig. 2), concentrating on fish health and population sizes, water chemistry, water pollution problems, as well as hydrological and hydrobiological factors.

Causes: Three historical events have played a key role in shaping today's appearance of the Old Aare and have led to the problems we observe today. The first "Correction of Jura Streams" (1868–1891) diverted the Aare into Bielersee via the Hagneck Canal. The formerly natural stream bed of the Aare between Aarberg and Meienried was transformed into a straight, artificial canal, which is since then called "Old Aare" (Fig. 2). The hydroelectric power plant Aarberg has been in operation since 1967. It regulates the flow in the Old Aare at a fixed volume of 3.5 m^3/s (since 1973). In 1968, the wastewater treatment plant (ARA) Lyss began operations, using the Old Aare as its receiving body.

Consequences: Consequences for the Old Aare ecosystem are all closely linked to one another (Fig. 3). Due to the constant flow volume and its canal-like structure, the Old Aare flows evenly and relatively rapidly. This results in a severe deficit of structure and habitat diversity for the stream fauna. Resting zones and areas of standing water are absent entirely, which has an impact on breeding and young fish in particular. Flow control structures and the power plant Aarberg obstruct fish migration. The presence of the power plant also disrupts the natural transport of gravel (bed load), while the combination of a high concentration of suspended particles and a constant flow rate leads to severe colmation of the river bed. Natural reproduction of species laying their eggs in gravelly river bottoms is severely impacted. The constant flow regime and significant colmatation suppress dynamic processes typical of natural flood plains (e.g., periodic flooding). The forest in the flood plain of the Old Aare has nationally been designated as "important", but is in serious danger of drying out and losing its species distribution and structure. Water quality is deteriorated even further due to the discharge of effluent from the ARA Lyss into the already impacted Old Aare. Frothing, increased turbidity, odors, oxygen depletion and the growth of fungi originating from the wastewater can often be observed. Below the ARA Lyss, the Old Aare can be considered moderately to heavily impacted. The most problematic contaminants in the effluent from the ARA Lyss are nitrogen compounds, organic substances, and bacterial counts, which can be present in precariously high concentrations. Toxicity tests indicate problems with cell- and genotoxicity as well as endocrine activity. Additionally, the Old Aare is impacted by seepage from waste disposal sites and by diffuse discharges from agriculture. A stress factor, particularly important for trout, is the high water temperature (>21 °C) observed during the summer months. These unnaturally high temperatures are caused by the numerous dammed sections of the Old Aare (Wohlensee and dams at Niederried and near Aarberg) and the discharge of cooling water from the nuclear power plant at Mühleberg. The occurrence of "black trout" (the cause of the symptoms is as yet unknown) suggests that the high temperatures may have at least an "inducing potential" for this disease.

Remedial action: Of the 12 hypotheses that have been formulated, five apply to the Old Aare: a combination of a number of small effects (in part due to input of suspended particles and chemical pollution), habitat deficiencies, including obstacles to migration, disturbance of reproductive cycles, lack of offspring and increased water temperatures. Several measures will be needed to restore health in the fish populations and to increase diversity and numbers to desired levels (Fig. 3). Improvements in the morphology of the river bed are already planned as required by regulations on the protection of flood plains. Structural changes at the hydroelectric power plant Aarberg, allowing fish migration and creating a dynamic flow regime, are in the planning stages, in part as a result of the project "Green Electricity". Water quality will be improved by revisions to the ARA Lyss, which are also currently in progress.

Outlook: The project Fishnet was designed according to the requirements for integrated stream management as described in the article of U. Bundi and B. Truffer (p. 3). The case of the Old Aare is an example of a "synthesis project". It demonstrates that it is possible to develop a remedial action plan based on input from a wide variety of experts. The next steps, namely realization and evaluation, will reveal the success of the overall approach.

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Further information on the project Fishnet under www.fischnetz.ch and in the publications "fischnetz-info".

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