

# “ÖKOSTROM”: SYSTEM OVERVIEW AS A TOOL TO ASSESS THE EFFECTS OF HYDROPOWER GENERATION ON RIVERS: ECO-MORPHOLOGICAL, HYDROLOGICAL AND FISHBIOLOGICAL ANALYSIS

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## Introduction

Switzerland has an average precipitation of 1500 mm per year and the country is rich in water. Flow modification in running waters is one of the most wide-spread anthropogenic influence in the alpine region. Hydropower development in the Swiss Alps is extensive, concerns almost all catchments and is one of the major causes of flow modifications. In order to assess the effect of hydroelectrical dams and water diversions on Brenno River and its fish fauna eco-morphological, hydrological and fishecological analyses were carried out on the whole river system. Brenno River is situated in the southern part of Switzerland and has an alpine catchment area of 407 km<sup>2</sup>. Before intensive studies on streamflow–habitat relationships are carried out, the important and sensitive reaches for the survival of key species have to be identified. The system overview is a cost-effective survey providing more detailed information on anthropogenically modified stream reaches.

## Methods

*The eco-morphological analysis* was carried out in upstream direction (mouth-headwaters direction) with a focus on the main channel including analysis of different parameters: longitudinal connectivity, migrations barriers for fishes, variation of width and water depth as parameters for habitat heterogeneity, substrate, importance of lateral connectivity, riparian vegetation, and land use. 50 different stream reaches were identified and a point scoring was carried out, and the reaches were arranged according to their naturalness in four different classes (class 1: natural/near natural, class 2: little affected, class 3: strongly affected, class 4: artificial stream conditions). To present an overview, maps are drawn with different colors for the four classes. The maps are completed with additional information (e.g. natural and artificial migration barriers for fish, riparian conditions etc.)

*The hydrological analysis* mainly consists in an inventory of all the water abstractions and reservoirs to record dry stream beds and minimum flow reaches. 23 sites with water abstractions were identified. All the different reaches of the main river and all the tributaries were classified according to their water flow in four different classes (natural discharge – reaches with minimum flow – reaches with severe minimum flow problems – reaches that drain temporarily).

### *Fishecological analysis*

In order to analyze the distribution of fish species point abundance sampling in different reaches was carried out by electroshocking. This sampling procedure is simple and allows a large number of sites to be studied within a short time. At special areas of interest (e. g. reaches with severe minimum flow problems) the time-consuming removal method with 3 consecutive runs was carried out (DeLury Method). With this method it is possible to estimate the size (abundance/biomass) and structure of fish populations.

## Results

### Eco-morphology

To sum up one may say that Brenno River and its tributaries are in quite natural conditions. Although there are 2 reaches that have to be classified as strongly effected (10 % of total stream length), stream morphology is not the main ecological problem.

Some migration barriers have a detrimental effect on the longitudinal connectivity. With the existing two artificial barriers in reach 7, only 4.8 km from the junction of the river can be reached and used by spawning brown trout (*Salmo trutta fario*) and lake resident trout (*Salmo trutta lacustris*). If these two barriers could be removed a total of 18 km would be accessible for migrating brown trout.

Reach 7 is 3078 m long and shows quite severe habitat degradation. The pool-riffle-sequences are not existing anymore and habitat for brown trout and grayling (*Thymallus thymallus*) is very scarce.

### Hydrology

In comparison with stream morphology the hydrology has to be considered as highly affected by mankind. 17 out of 23 water diversion reaches do not have a minimum flow regulation. These sites are temporarily or permanently without any water flow. For about 50 % of the reaches there is no problem for fishes because these streams have a very high gradient and are not inhabited by fish. However, the effect on the benthic community is not known.

92 % of the length of the main river do not have a natural flow regime anymore and are considered to be minimum flow reaches.

### Fish ecology

9 fish species (7 native and 2 exotic species) were found in the whole river system. Brown trout is the most abundant species and occurs potentially in all streams (except the streams with a very high gradient and lack of water flow). In the lower part of the river (about 8 km upstream of the junction) all 9 fish species potentially occur. The remaining 29.2 km of the main river are only colonized by brown trout. In one tributary we also found brook trout *Salvelinus fontinalis*.

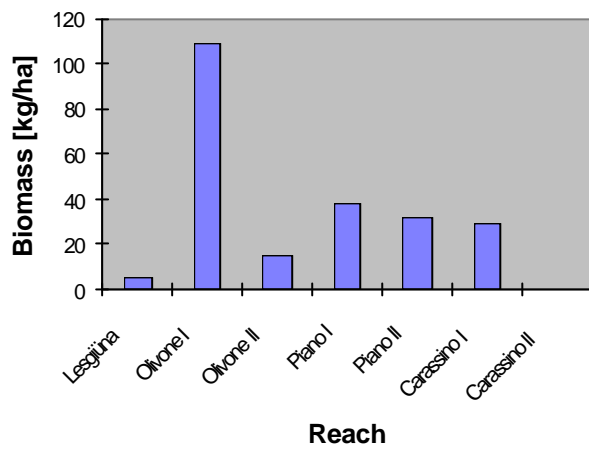
The most diverse fish community (number of species, occurrence of red list species, and population structures) was observed in the lowest floodplain (3.6 km from the junction with Ticino River).

A comparison between a channelized river reach having very strongly reduced habitat structure and a floodplain reach with high habitat heterogeneity showed a decrease of fish biomass of 60 % in the channelized river reach. In addition 2 fish species (grayling and soufie (*Leuciscus souffia*)) disappeared and the age structure of brown trout was negatively affected.

Fish abundance and biomass in seven typical minimum flow sections were distinctly different (table 1 and figure 1).

Stream section	Abundance (N per ha)
Lesgiüna	50
Olivone I	3118
Piano I	572
Piano II	503
Olivone II	237
Carassino I	398
Carassino II	0

**Table 1** Trout abundance in 7 different minimum flow sections



**Figure 1** Trout biomass in 7 different minimum flow sections

## Conclusion

Fishes showed distinct reactions to stream channelization. High quality habitat in the floodplain are inhabited by a diverse fish community. On the contrary degraded habitats have low species number and low abundance and biomass. The analysis of the longitudinal connectivity plays an important role in the colonization of stream reaches and determines fragmented stream areas.

Relating to water diversion and related minimum flow the reaction of the fish population is not clear yet with the system overview. Further, more intensive studies are needed. The minimum biomass was 0 kg/ha (no fish), on the other hand the maximum biomass was 109 kg/ha.

In order to study habitat suitability curves and methods to establish minimum flows different minimum flow sections should be included. At least the reaches with the extreme values should be considered.

The system overview makes it possible to identify ecological problems concerning habitat, stream flow and key species. For the identified key species habitat modeling is recommended in the reaches of high interest and high ecological importance. Mainly the minimum flow section Olivone I could document the hydrological and morphological needs of different age classes of brown trout. The results of the system overview support the certification procedure of green hydropower as mentioned in former lectures concerning the "Oekoström" project.