”ÖKOSTROM”: FIELD STUDY AND USE OF THE SIMULATION MODEL CASIMIR FOR FISH HABITAT FORECASTING IN RIVER BRENNO THEME E

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Introduction

One of the major effects on rivers caused by hydroenergy production is the change of hydraulic habitat for fish. Quantifying the quality and availability of fish habitat dependent on the discharge can therefore be very helpful to estimate the impact of a hydro power plant on river ecology. Especially in alpine regions knowledge about this impact is essential for the development of instream flow regulations because the decrease of energy production in hydro power plants with high head caused by the so called minimum flow left in the river is considerable. Even though it is known that hydraulic and morphological factors play an important role for aquatic habitat, especially in Central Europe still little is known about the demands of domestic fish concerning these factors.
In order to contribute to closing this gap during the last ten years at the University of Stuttgart the simulation model CASIMIR (Computer Aided SImulation Model for Instream flow Regulations) was developped with the objective to realize the mentioned quantification. Within the ÖKOSTROM-Project CASIMIR was tested for the first time in alpine rivers. The forecast of hydraulic habitat availability for fish and its changes caused by discharge variation can deliver valuable information for the determination of instream flow regulations.

Methods

The CASIMIR module SORAS (Structure Orientated River Analysing System) uses cross-section information of a river stretch and can calculate and visualize fish habitat changes as a function of discharge. Within the cross-section not only geometrical

information but also structural information like subtrate sizes, cover categories, pool types, single rocks etc. are recorded. Water surface levels are given by measurements or one-dimensional calculation, local velocities are determined with a robust approach considering bottom roughness, water depth and water surface slope.

The classic approach for integrating habitat preferences in habitat prediction models is the use of preference curves giving certain suitabilities for physical parameters like water depth, flow velocity, substrate etc.. The suitabilities are calculated separately for each parameter and then are connected by different methods for example regarding the minimum, maximum or mean of the calculated values.
But, as a matter of fact, the combination of the physical parameters plays a major role for fish habitat quality. A location in a river stretch with optimum suitability regarding substrate and flow velocity will not be used if the water depth is too low. On the other hand even a small water depth can be accepted if convenient cover can be found.
To take this into account fuzzy rules were developped in a first state including the four parameters water depth, substrate, flow velocity and cover. Using a fuzzy approach gives the advantage, that the rules building the base for determining the suitability can be build verbally saying e.g. "if the water depth is medium, the flow velocity is relatively low, substrate is small and no cover is provided then suitability for a given species is medium". This way of expressing a habitat demand can include lots of combinations and nevertheless is easier to be handled because it's closer to human thinking than finding regression functions and preferences, which comprise discrete numbers, and considering them as isolated parameters.
Field studies and fishing were performed to determine the habitat demands of several fish species. SORAS was used to calculate and visualize the habitat availability, its development with discharge variation and to find additional parameters influencing the habitat quality.

Results

First habitat forecasts using a) preference functions and b) a fuzzy approach integrating substrate, water depth and flow velocity and fishing in two morphologically different stretches of river Brenno showed, that frequency of brown trout is highly dependent as well on structural conditions as on discharge. In the section "Loderio floodplain" with a high diversity simulation results showed areas with high habitat quality, which could be increased by higher discharge. Fishing results confirmed the simulations and "hot spots" were found especially close to certain pool and cover types.
In contrast the straightened relatively uniform river stretch "Loderio channel reach" was predicted by the model to be in most parts highly unsuitable because of small depths and high hydraulic stress. The developments of the weighted usable area (WUA) as an integrated value of habitat availability received by the two simulation approaches were similar for the stretch "Loderio floodplain", though on different levels. In contrast the WUA-functions in the "Loderio channel reach" were significantly different. The reason is that the preference curves based approach is not able to consider the varity of physical parameter combinations.
Habitat forecast were coupled with time series of historical flow. Results indicate that the investigated stretches are not principally critical concerning reduction of hydraulic

habitat by minimum flow. However especially during the winter months and after the melting of snow there are periods requiring higher instream flows.

Conclusions

Investigations performed with the simulation model CASIMIR in two morphologically different reaches of river Brenno in the Suisse alps confirm that physical habitat availability for fish is one of the major factors to be considered in instream flow regulations. Physical habitat is strongly dependent as well on morphology as on discharge.

The varity of physical parameter combinations is an important aspect for habitat quality. A new approach based on fuzzy logical methods is capable of integrating this factor into habitat modelling and simulations showed a good agreement with hot spots recorded by electro fishing.

Summarized the simulation results give valuable information within the certification process for hydro power plants and by integrating temporal aspects the model output is a major support in the assessment of dynamic instream flow regulations.

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