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Effects of experimental flooding on the River Spöl, Swiss National Park

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Abstract

Following the construction of two reservoirs in the late 1960s, the discharge of the River Spöl, Swiss National Park was reduced and regulated. Elimination of river changing floods caused a degradation of river morphology and of habitat conditions for benthos and brown trout (*Salmo trutta* L.). In 1996 a flood program was implemented to enhance ecological conditions in the Spöl River. Due to the experimental floods (since 2000), most alluvial fans in the channel were scoured downstream, bed sediments were less embedded, and variation in channel depth increased. Macroinvertebrate densities were reduced up to 90%. Recovery to pre-flood densities occurred within few weeks but the species composition changed significantly. Fish abundance was not reduced by the floods and only few fish were killed or stranded. The quality of fish habitat, spawning grounds in particular, was noticeable improved. The condition of trout remained relatively constant, even though food resources were altered to some degree.

Keywords

river management, flow regime, flushing flood, colmation, macroinvertebrates, fish stock, spawning conditions, Swiss National Park, Salmo trutta

Project aims and Duration

The experimental flood program aimed at testing an annual flood regime intending to restore riverine dynamics. Investigatins focused on how floods must be managed in order to cause minimal, yet regular flow disturbance which is required to maintain riverine dynamics in a near natural state.

Representatives of the Engadin Hydroelectric Power Company, the Swiss National park, regional Fisheries authorities and hydrobiologists developed a program concerning these experimental floods. This program included a slight reduction of the residual water discharge and the storage of this water for flushing floods. The calculations were based on the different energetic values of the two reservoirs. Finally no losses of energy-equivalents resulted from the flushing program.

The effects of the experimental floods were studied by several working groups (EAWAG, University Berne, Hydra). On the basis of the results of the first three years (2000-2002) the dynamic residual flow regime was optimized and maintained in subsequent years.

Study area

The Spöl River flows from the central alpine Bernina massif to the Inn River, a tributary of the Danube (fig.1). The National Park of Stelvio (Italy) and the Swiss National park encompass a major portion (> 80 %) of the catchment area. Following a fierce political campaign in 1956, Switzerland and Italy agreed to use the Spöl for hydroelectric production even though the river was part of the Swiss National park then. The Punt dal Gall dam and the Ova Spin dam were finally completed in 1970.

Before regulation, the Spöl River had an average annual discharge between 6.6 and 12.5 m^3/s and peak discharge reaching 36 to 140 m^3/s. Following dam completion, discharge was regulated at average 1 m^3/s from Livigno reservoir and average 0,6 m^3/s from Ova Spin reservoir. Since 2000, residual flow in Spöl River is reduced slightly and 1-3 floods (maximum discharge: 11-45 m^3/s) are released from the two reservoirs during summer (fig. 2).

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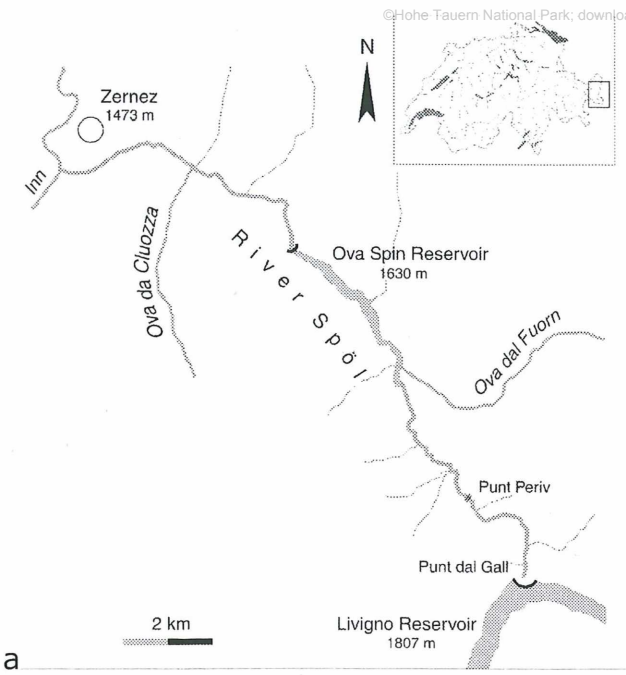

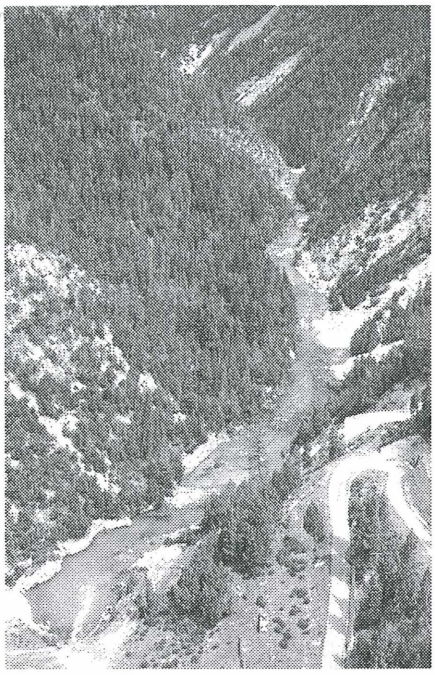

Fig. 1: a. River Spöl in the study area

b. River Spöl view from Punt dal Gall dam

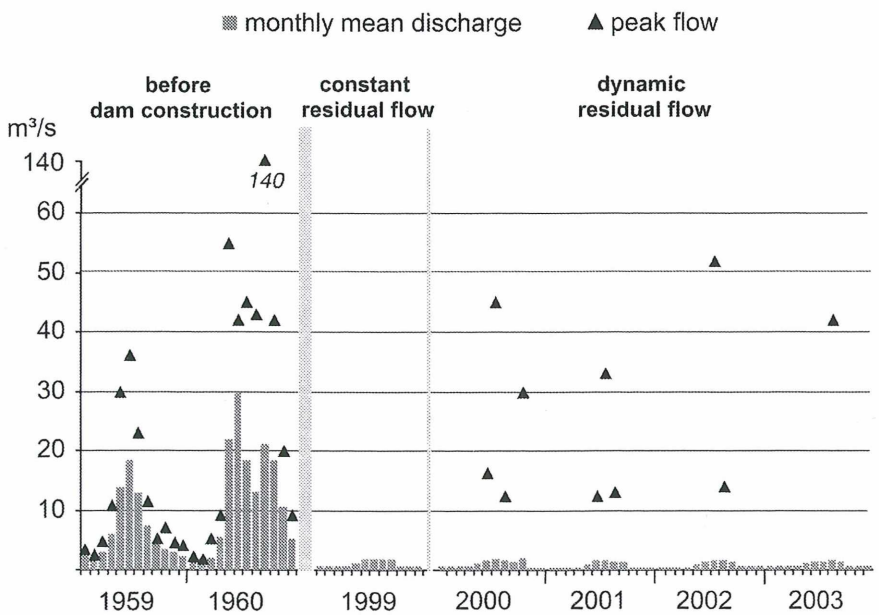

Fig. 2: Discharge of river Spöl (Pt. d. Gall)

Methods

Suspended sediment was determined using IMHOFF funnels. Substrate transport was observed using marked substrata of 2 to 30 cm diameter.

Changes of river morphology, riverbed structure, sediments, and macroinvertebrate abundance were observed before the floods and after each flood. Morphology and substrate characteristics were mapped. 38 transects were measured (theodolit). At selected transects the bottom substrata was mapped and the degree of colmation was categorized. Sediment samples were taken at 15 sites by means of a Surber sampler, the particle size distribution was determined by sieving. Sediment freeze cores were taken to assess the sediment structure of deeper layers.

The macroinvertebrates of the Spöl were collected twice a year since 1996 at 6 sample sites. Additional samples were taken before and after each flood (EAWAG).

The fish stocks were examined before and after floods using electro-fishing. The loss of fish was estimated after each flood by counting dead or stranded fish. The spawning redds of trout from Livigno reservoir to Punt Periv (2.7 km) were mapped annually at the end of November.

Results

The highest concentrations of suspended sediments (17.5 ml/l) occured during the first flood in June 2000, during following floods sediment volume was mostly less than 4 ml/l. Maximum concentrations occurred during the rising limb of each flood. Gradully increasing concentrations of suspended sediments were observed downstream, indicating that the input of lake sediment was negligible.

The floods caused a significant removal of sediments at the foot of debris fans within the active channel (fig.3). The mobilization of material from the debris fans resulted in extensive accumulations of gravel and sand in the riverbed and adjacent floodplains in the first flood year. The floods of the following years scoured newly built gravel banks and further eroded benthic sediments. A greater variation (coefficient of variation in %) in water depths, suggesting an increase in habitat variability, was measured after the floods.

Gravel and cobble are the predominant sediment classes in the Spöl. The average D50-value before the floods was 62 mm, increasing to about 76 mm after the first flood year. The floods changed the substrate composition, slightly increasing coarse sediments by erosion and gravel by deposition. The percentage of fine material (silt, sand) in the upper layer of substratum was reduced, as indicated by the reduction in substrate colmation (fig. 4). However, besides reducing the amount of fines in bed sediments, other colmated areas were covered with loose gravel.

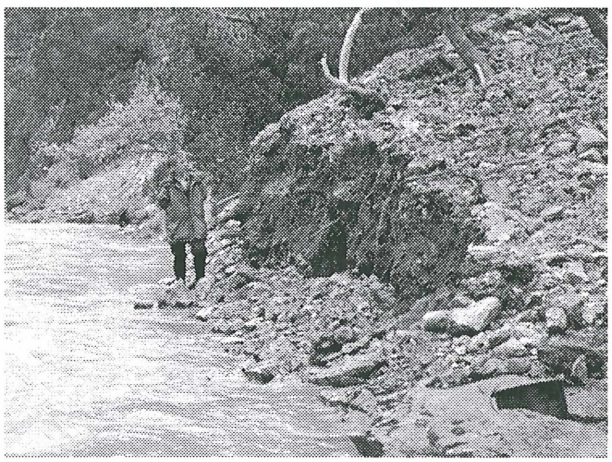

Fig. 3: Debris fan, eroded by the experimental floods

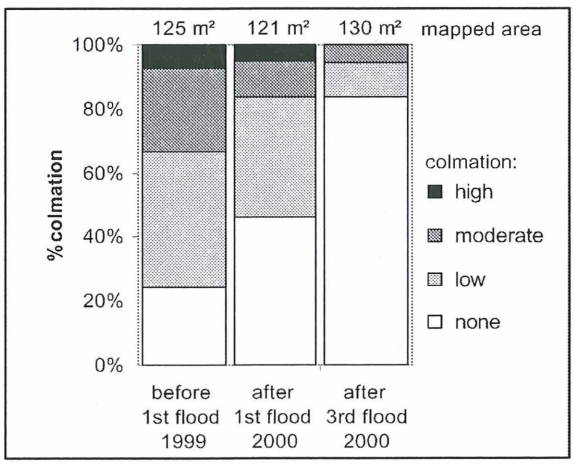

Fig. 4: Substrate colmation

Stability of river bottom and enhanced growth of aquatic plants favoured the mass occurrence of *Gammarus fossarum* and *Crenobia alpina* during constant residual flow regime. With the artificial floods macroinvertebrate densities were reduced up to 90% - depending on discharge, yet recovery to pre-flood densities occurred within a few weeks (ROBINSON et al. 2003). The species composition changed: the abundance of may- and stoneflies increased, while the abundance of *Gammarus fossarum* and *Crenobia alpina* decreased.

Fish abundance was not reduced by the floods and few fish (<2%) were killed or stranded. The quality of fish habitat, spawning grounds in particular, was noticeable improved. Food resources were altered to some degree. The condition of trout remained relatively constant (condition factor 1). In the 2.7 km long study section downstream of Livigno reservoir the number of redds increased about four-fold since initiation of the flood program (fig. 5).

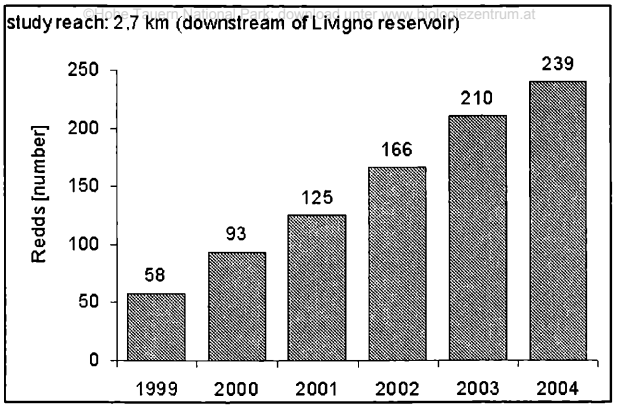

Fig. 5: number of redds

Conclusions

The numerous changes in river morphology and habitats show that a flood regime program can mitigate the negative consequences of a reduced and regulated discharge. However, the desired effects occur solely with a frequent number of relatively high magnitude floods. The number and magnitude of future floods can be determined after assessing the sediment input from the side-slope tributaries and debris slopes in an adaptive management approach. Further efforts towards optimizing a dynamic discharge regime should consider the biological effects like the substantial algal development of the residual water regime.

Acknowledgements

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Appendix

Does the flood of data, as well as the current methods and standards really help the practitioners and those who are responsible?
In the case of River Spöl, research activities were initialised by practical problems: the need of artificial flows to flush reservoirs as well as the river bed. Up to this time scarce local data were available to implement a program for flushing floods.

What results does research in Protected Areas need to achieve to be useful for Protected Area Management at the best?
To evaluate the influence of the flushing flows on different morphological and biological components of the river, it was of special importance to have a pool of data that describe the status and limits of variation of these biological, hydrochemical and morphological components. We had to collect most of these data within one year, what is very little time to explore biological fluctuations. Moreover, access to original data or biological samples was required.

Did the remarkable scientific achievements of the protected areas successfully anchor in the minds of the general public?
The local residents are very interested in the scientific and applied research in the national park. This is demonstrated by the well attended information events in the Nationalparkhaus in Zernez.

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