Task B

Ecological impacts

Task B1: Invertebrates. Invertebrates are important parts of aquatic ecosystems and important prey for fish and other organisms. Knowledge on how hydropeaking and increased river regulation affects the invertebrate fauna is thus fundamental to operate hydropower production in an ecologically sustainable way. Invertebrate species compositions are now also used as criteria on how to characterize the ecological status of different water bodies according to the EU Water Framework Directive. Also being the most important prey for most fish species, knowledge on how hydropeaking and alternative river regulation affects the invertebrate fauna is needed for input to fish population models and the categorization of negative ecological impacts.

Task B2: Freshwater pearl mussel. The nationally and internationally red-listed freshwater pearl mussel may also be affected, both directly through modification of their habitat, and indirectly through impact on the fish (salmon or trout) which are obligatory hosts for the parasitic larvae. The impacts on the habitat of the extremely long-lived mussel are mainly related to periodic dessication or dewatering, ice-scouring and sedimentation.

Task B3: Salmonid fish. Hydropeaking may on one hand cause immediate fish mortality due to stranding or delayed mortality due to increased vulnerability to diseases or reduced performance (e.g. growth, swimming performance) caused by damage during stranding. On the other hand, if fish do not strand their performance may be influenced by the physical and biological changes associated with hydropeaking and increased regulation. Highly variable physical conditions may influence, spawning, early survival and cause reduced growth or storage of fat reserves, potentially affecting their survival. Changes in the invertebrate fauna may affect feeding conditions and thus growth, whereas changes in abundance and behaviour of mammals and birds may influence predation risk. However, salmonid fishes are strongly density regulated during their freshwater phase. Thus, to be able to assess the effects of hydropeaking and increased regulation we need to understand how density processes interact with the physical changes associated with increased regulation. Without such knowledge the population effects of extra mortality due to hydropeaking or increased regulation cannot be assessed. Based on the current state of knowledge and ongoing research in affiliated projects we have prioritized the following subtasks.

Subtask B3.1: Spawning and early life stages. The availability and distribution of spawning habitats are important for salmonid production. Large fluctuations in flow over short time scales lead to inconsistent availability of suitable spawning habitat. The behavioural response to these unnatural conditions is likely to impact the distribution of nests and thereby affect spawning success. The quality of the habitat en-

countered by the fry after swim-up is likely a main factor regulating salmonid populations. Due to their restricted mobility, newly emerged fry are especially susceptible to rapid changes in flow. The resulting nest distribution and egg-survival will be assessed during winter and spring.

Subtask B3.2: Density dependent habitat use and susceptibility to standing of different size groups. To be able to assess the population level effects of hydropeaking we need to know what size groups of fish are most susceptible to standing and most heavily influenced by the variable physical conditions under hydropeaking and increased regulation. Habitat selection is a dynamic process influenced by environmental conditions, behavioural constraints, conspecific densities, competitors and predators only partly described in the literature.

Subtask B3.3: Long-term survival and performance of stranded fish. Stranding mortality and rules of thumb for acceptable dewatering rates has been developed Relative small stress responses to drops in discharge and moderate effects of fluctuating water levels on feeding and growth have been found in laboratory settings. However, long term survival of stranded but not killed fish has never Environmental impacts of hydropeaking KMB proposal for RENERGI 2008 4
been studied. Moreover, the long term performance effects on growth and energetics of hydropeaking have not been studied *in situ.*

Subtask B3.4: Population level effects. It is now well established that density regulation is very strong during the first weeks after swim-up, whereas little is known about the strength of the regulation for larger fish. Moreover, the relative importance of intra- and intercohort competition for the density regulation is largely unknown. Extra mortality prior to density regulated life stages may not influence fish production, whereas extra mortality during stages where density regulation is weak may strongly influence production. Understanding the dynamics of density regulation of salmonids is a major challenge which cannot be accomplished within the present project. However, through joint efforts with affiliated projects we aim at providing at least a qualitative understanding of density processes sufficient for the population modeling under task D.

Task B4. Birds and mammals. Birds and semi-aquatic mammal species, such as otter and beaver, are functionally important to riverine ecosystems. In part they are predators depending on fish and invertebrates, and thus influencing fish populations (otter and birds as mergansers and gulls), and in part they influence the habitat itself by logging and creating wetland areas by damming (beaver). The alterations in habitat due to rapid flow changes as a result of hydropeaking and accidental stops are likely to affect habitat use of these animals. Hunting and scavenging opportunities for otters and birds are also likely to be affected by the local shifts in fish and invertebrate abundance. There are no known studies on habitat use and foraging strategies of otter and little on beaver and birds in hydropeaking rivers. The fundamental questions are i) how do rivers subjected to hydropeaking and accidental fallouts affect activity of semi-aquatic mammals and birds compared to rivers not subjected to

these water fluctuations; ii) will these rapid flow changes attract other bird species; and iii) to what extent will these birds and mammals influence the river environment?