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The impact of a regulated flow regime on stream morphology and habitat

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Many rivers have flow regimes that are regulated for hydropower production. Such regulation is generally assumed to lead to river bed degradation and armouring, increased morphological stability and to a decline in habitat diversity. This final point usually implies a reduction in the overall ecological status of the affected reaches. However, some species have specific habitat requirements that are sensitive to hydrological regime and that may be enhanced by flow regulation. One such species is the freshwater pearl mussel (*Margaritifera margaritifera*), an endangered species that has experienced a significant decline across Europe over the past few decades.

The River Kerry in north-west Scotland is a small ($47 km^2$) catchment containing a natural lake. This lake was dammed in the early 1950s during construction of a hydropower plant, leading to a heavily modified flow regime. The Kerry is home to the largest population of pearl mussel in the UK, estimated at over 400 000 individuals, and is designated as a Special Area of Conservation on account of this population. The channel is largely confined by bedrock outcrops, and short alluvial reaches have been historically stable. Short stretches of localised bank erosion at the present day are causing channel changes to occur at rates that are similar to those observed historically. The channel bed material is largely gravel with a small ($<10\%$) amount of sand and very little silt and clay. The bed is quite stable, even during large floods which overtop the dam, providing ideal habitat for adult mussels. Juveniles establish themselves in sandy patches that are found downstream of areas of local bank erosion.

The impact of regulation on flow regime has been to reduce the peak magnitude and frequency of occurrence of flood events (defined as those events that are competent to mobilise the bed surface material), and to provide a steady minimum flow throughout

most of the year. Such a regime, in particular the absence of both bedload transporting and low flow events, appears to favour the mussel population. The natural lake in the headwaters provides a sediment trap, such that sediment throughput is low and bed aggradation and degradation are restricted. This situation also benefits the mussels, as does the absence of significant fine material in suspension due to both catchment geology and upstream trapping. The long-term viability of the mussel population is also dependent on salmonid fish species, as the juvenile mussels are parasitic to these fish for the first c.6 months of their life cycle. Flow regulation is likely to have affected the habitat for these fish, but they also use unregulated small tributaries for spawning, and a viable fish population is being maintained. Thus, the modified flow regime appears, after 50 years, to have produced an enhanced habitat for a significant species and this habitat appears to have medium-term viability.

The River Kerry case illustrates the potential complexity of interactions between flow regime and stream ecology. Without data from prior to 1950 it is impossible to know whether habitat diversity was adversely affected by regulation. However, in a period of elimination of the pearl mussel from many streams in NW Europe the maintenance of the mussel population at this site suggests specific benefits arising from flow regulation for this species. Such a finding raises important issues regarding instream ecology and the need to balance the overall ecological status of individual rivers with the regional status of particular species.