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Assessing the eco-hydraulic effects of a hydropeaking mitigation measure with increased energy production in the Noce River (Italian Alps)

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We investigated the ecohydraulic effects of a recently implemented hydropeaking mitigation measure in the Upper Noce Stream (NE Italy, Italian Alps), which also allows for additional hydropower production. The Upper Noce, a 3rd order gravel-bed stream, was affected since the mid-1920s by storage hydropower production and associated hydropeaking. The mitigation measure consisted in the diversion of most of the released hydropeaks into a sequence of three newly-installed, cascading run-of-the-river power plants, fed by a penstock running almost parallel to the former hydropeaking reach. The hydropeaking-diversion mitigation measure markedly reduced hydropeaking on a 10-km stream reach, and hydropeaking is now released immediately upstream the confluence with a major free-flowing tributary, which increases the hydropeaking baseflow. The flow regime in the mitigated reach shifted from hydropeaking-dominated to baseflow-dominated regime in winter, with flow variability represented only by snowmelt and rainfall in late spring and summer. We applied two sets of indicators (the Hydropeaking Indicators HP1, HP2 and the COSH method) and conducted a simplified hydraulic analysis of the hydropeaking wave propagation. We assessed the ecological effects of the mitigation measure using three complementary data sources: the analysis of (a) the benthic and (b) hyporheic invertebrate communities, based on datasets collected before and after the implementation of the diversion measure, and (c) ancillary data monitored by the diversion plant manager for required environmental monitoring, which included the suspended sediment regime and the Extended Biotic Index, measured yearly from the year before to the four subsequent years after the implementation of the mitigation measure.

Three main changes in eco-hydraulic processes associated with hydropeaking mitigation were detected. i) The flow regime in the mitigated reach changed to a residual flow type, with much less frequent residual hydropeaks, with an average two-fold increase in downramping rates that were recorded downstream the junction with a major tributary. ii) The functional composition of the macrobenthic communities shifted slightly in response to flow mitigation, but the taxonomic composition did not recover to conditions typical of more natural flow regimes. This was likely due to the reduced dilution of pollutants and resulting slight worsening in water quality. iii) The

hyporheic communities conversely showed an increase in diversity and abundance of interstitial taxa, especially in the sites most affected by hydropeaking, and this effect was likely due to changes in the interstitial space availability, brought by an alteration of the previous time-space pattern of fine sediment transport, which eventually resulted in reduction of fine sediments clogging of the gravel bed interstices.

Besides illustrating a feasible hydropeaking mitigation option for Alpine streams, this work suggests the importance of monitoring both benthic and hyporheic communities, together with the flow and sediment supply regimes, and physico-chemical water quality parameters, for carefully detecting changes in eco-hydraulic processes associated with hydropeaking mitigation that may not be fully expected in the design phase.