



Khamis Kieran, David Hannah, Rocco Tiberti, Lee Brown, Alexander Milner. 2014. The use of invertebrates as indicators of environmental change in alpine rivers and lakes. *Science of the Total Environment*, 493: 1242-1254

In alpine regions climatic change will alter the balance between water sources (rainfall, ice-melt, snowmelt, and groundwater) for aquatic systems, particularly modifying the relative contributions of meltwater, groundwater and rain to both rivers and lakes. While these changes are expected to have implications for alpine aquatic ecosystems, little is known about potential ecological tipping points and associated indicator taxa. We examined changes in biotic communities along a gradient of glacier influence for two study systems: (1) a stream network in the French Pyrénées; and (2) a network of lakes in the Italian Alps, with the aim of identifying potential indicator taxa (macroinvertebrates and zooplankton) of glacier retreat in these environments. To assess parallels in biotic responses across streams and lakes, both primary data and findings from other publications were synthesised. Using TITAN (Threshold Indicator Taxa ANalysis) changes in community composition of river taxa were identified at thresholds of <5.1% glacier cover and <66.6% meltwater contribution. Below these thresholds the loss of cold stenothermic benthic invertebrate taxa, *Diamesa* spp. and the Pyrenean endemic *Rhyacophila angelieri* was apparent. Some generalist taxa including *Protonemura* sp., *Perla grandis*, *Baetis alpinus*, *Rhithrogena loyolaea* and *Microspectra* sp. increased when glacier cover was <2.7% and <52% meltwater. Patterns were not as distinct for the alpine lakes, due to fewer sampling sites; however, *Daphnia longispina* grp. and the benthic invertebrate groups Plectoptera and Planaria were identified as potential indicator taxa. While further work is required to assess potential indicator taxa for alpine lake systems, findings from alpine river systems were consistent between methods for assessing glacier influence (meltwater contribution/glacier cover). Hence, it is clear that TITAN could become a useful management tool, enabling: (i) the identification of taxa particularly sensitive to glacier retreat; and (ii) conservation efforts/resources to be better directed in alpine aquatic systems.