

## Lessons learned from invasive fish research in the Waikato

Kevin Collier, Nick Ling, Brendan Hicks

Invasive fish have a variety of effects on indigenous fish communities and freshwater ecosystems generally, and the magnitude of these effects is partly dependent on invasive fish biomass. For example, a koi carp biomass of 120–130 kg/ha was sufficient to depress macroinvertebrate and plant biomass, and to elevate chlorophyll a concentrations. Fishing is useful for establishing population structure, density, and biomass but is usually an ineffective way to reduce fish biomass to below the threshold conditions for spontaneous lake restoration in all but the smallest water bodies. Intensive fishing of European (redfin) perch in the 2.3-ha lower Karori Reservoir removed 54% of the perch visible to echo sounding but simply served to increase survival of juveniles in the following year.

One effective intervention in NZ has been the application of a one-way gate that lets carp leave Lake Ohinewai but prevents their return. This exploits the migratory behaviour of carp, as about 70% of adult carp leave shallow lakes seasonally for riverine habitats and return prior to spawning. Mark-recapture population estimates suggest that a combination of fishing and the one-way gate reduced carp biomass from 374 to 10 kg/ha. About half the biomass reduction was attributable to each method.

Invasive fish can reach 300-400 kg/ha in Waikato rivers, 80-90% of which is carp and about 10% is goldfish. In Waikato shallow lakes, goldfish frequently outnumber carp and comprised 556 kg/ha in Lake Mangahia, a 10-ha peat lake. At high biomasses such as this fish can have ecosystem-level effects. Nutrient excretion and catchment modelling suggest that koi carp contribute 9% of the nitrogen and 21% of the phosphorus inputs in Lake Ohinewai. Collectively, these studies highlight that invasive fish have the potential to constrain restoration outcomes in lakes and multiple methods are required to achieve long-term reduction in fish biomass.