than water, which makes the oxygen easier to extract. Clearly, leaving the water is an extreme measure that could place fish at risk of predation or desiccation in their natural environment. However, it may be an effective adaptation for short-term pulses of hypoxia, especially where cover is available.

In the surfacing behaviour seen in these experiments fish could be either breaking the surface to gulp air, or moving up to breathe in the surface water where oxygen levels are higher than those in the rest of the water column. Although both behaviours are energetically expensive because fish must maintain position at the surface, aquatic surface respiration allows fish to survive during periods of low oxygen.

Torrentfish were the only species that did not respond to low levels of oxygen by surfacing. Although most remained sedentary on the bottom at 1 ppm, the rate of gill ventilation increased noticeably. Torrentfish generally inhabit shallow, fast-flowing water that is well oxygenated. It seems that they have not needed to develop strategies of surfacing in order to reach more highly oxygenated water. Their apparent tolerance of low oxygen environments is therefore surprising.

Future research

To function within their environments fish must be able to grow, survive, feed and reproduce. This study has concentrated on the survival of juveniles of some common native fish species during exposure to a constant level of dissolved oxygen. To set dissolved oxygen criteria for New Zealand's freshwater fish species, more species need to be tested and similar tests carried out with other life stages, especially eggs and larvae, which are known to be more sensitive than later stages (USEPA 1986). The effects of fluctuating dissolved oxygen levels (to mimic diurnal swings) should also be considered.

The sublethal effects of hypoxia, which could include reduced development and growth rates and avoidance behaviour that may result in fish leaving affected habitats, also need to be examined. It is important to recognise that levels of oxygen that have no apparent effect may become lethal when coupled with toxicants or other compounding factors. ■

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Further reading

Alabaster, J.S. & Lloyd, R. (1980). *Water Quality Criteria for Freshwater Fish.* Butterworths & Co., London. 297p.

USEPA (1986). Ambient Water Quality Criteria for Dissolved Oxygen. United States Environmental Protection Agency. Washington, DC.

NATIVE FRESHWATER FISH

Who ordered the *Austrosimulium* on *Egeria*?

Jody Richardson

Dave West

Glenys Croker

What's the favourite food of native fish? For inanga and smelt, two-winged flies seem to top the bill, at least in one North Island stream.

IT'S TRUE, *Austrosimulium* on *Egeria*, spiders surrounded by *Hygraula* coulis, or crunchy *Potamopyrgus* smothered in *Paracalliope* gravy ... these tasty treats and more were all on the menu for native fish at the Whakapipi Stream cafe. But who ate what, when, and which fish had the biggest helping?

Over the past year, Whakapipi Stream has been the focus of a multi-disiplinary NIWA study investigating interactions between water chemistry, aquatic plants, invertebrates and fish in an impacted lowland environment. In this article, we present a preliminary analysis of our summer diet studies on common smelt and inanga, and examine how the diets of these fish are influenced by the invertebrate community in this tributary of the Waikato River.

Study site

Whakapipi Stream drains agricultural land south of Pukekohe. A soft, muddy substrate, a lack of bankside shade, dense summer growths of aquatic plants such as *Egeria* (oxygen weed), and deep, slow-flowing, discoloured water characterise the stream.

The fish community inhabiting Whakapipi Stream is dense and varied. In summer, fish numbers ranged from over 250 to almost 600 fish per 100 m^2, with up to nine species being recorded. This easily exceeds the national average of 28 fish per 100 m^2 and five species per site, and is considered high even for low-elevation sites (see *Water & Atmosphere* 4(3):17–19). The community was dominated by inanga, shortfin eel and common bully in summer, with many migrating juvenile fish being caught early in the season. In winter, common bully predominated, while inanga virtually disappeared. Common smelt were present all year in relatively low numbers.