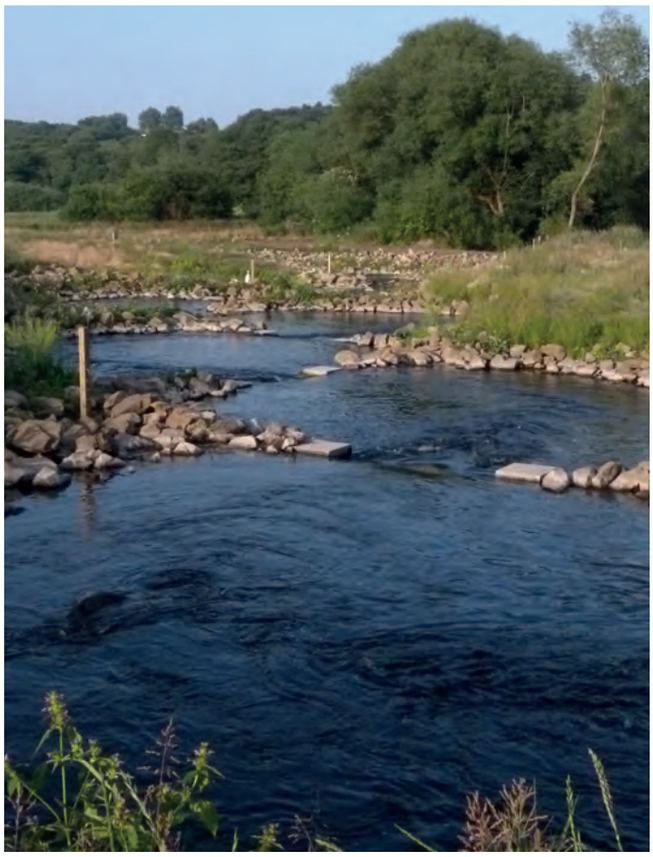
Figure 1. Nature-like bypass channel at Rodley Weir, River Aire (photo courtesy of ARUP).

Bypass Channels - do they work?

JAMIE DODD

Barriers such as weirs and dams disrupt fish migration routes, fragment fish populations, and are a major contributing factor to the extinction of fish species globally. There are almost 26,000 known barriers in English and Welsh waterways, each restricting or halting the movements of native fishes, including the humble river-resident brown trout. It is suspected that there are many more obstacles that we don't know about, particularly in the more remote, upland areas of the UK. For this reason the Scottish Environment Protection Agency (SEPA), the Rivers and Fisheries Trust for Scotland (RAFTS) and the Environment Agency (EA) have joined forces with the Nature Locator team to create a free-to-use mobile River Obstacles app for iPhone and android devices that enables people to send in photos and details of obstacles that they see when they're out and about either on, in or by the UK's rivers.

While little-studied, at least in comparison to anadromous sea trout and Atlantic salmon, it is known that brown trout undertake spawning migrations →



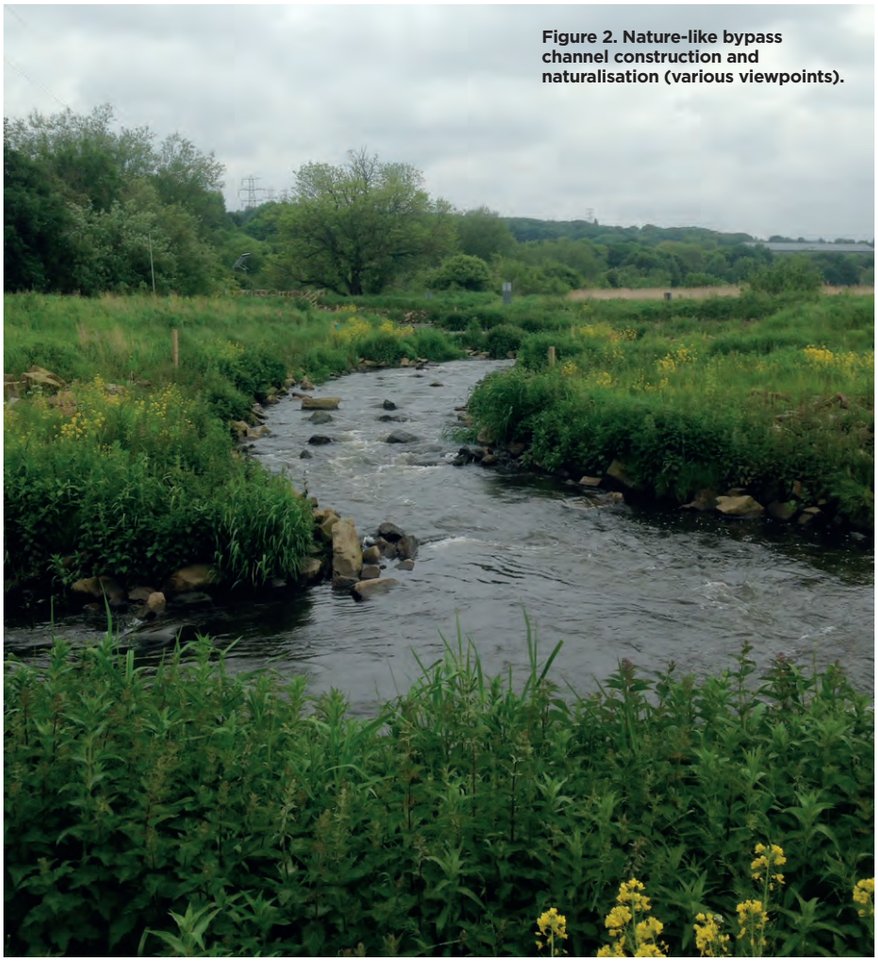


Figure 2. Nature-like bypass channel construction and naturalisation (various viewpoints).

and require good connectivity between habitats for feeding, for returning after displacement in high flow events, shelter from predators and flow refuge at different times of year and for different life stages. What is less well-known is how they respond to fish passes constructed to improve connectivity past man-made barriers that cannot be removed because of societal drivers. As followers of WTT, I'm sure readers are aware that barrier removal is occurring more and more frequently, in response to European legislation and increasing understanding of the negative impacts.

The River Aire, where this investigation was performed, has been fragmented by largely impassable man-made obstructions for centuries. For example, Chapel Haddlesey Weir, near Eggborough, has acted as a barrier to migratory fish since it was constructed in 1702, but the situation is about to change! In October 2017, the Aire Rivers Trust, in partnership with the EA, announced it had secured a £1.8 million development fund from the Heritage Lottery Fund. This exciting new project, called DNAire, will install fish passes on four of the remaining large weirs on the river, thus enabling the return of 'Salmon to Skipton' and their traditional spawning grounds in the headwaters.

Rodley Weir is 50m wide, 1.8m high and largely impassable to upstream migrating fish and an impediment to those headed

downstream. Indeed, the local nature reserve staff recounted many a tale of fish attempting to ascend the weir face but falling back without surmounting the crest. In 2013, Yorkshire Water constructed a nature-like bypass channel through Rodley Nature Reserve to improve connectivity of the River Aire. Nature-like bypass channels are believed to be more passable than engineered passes for both adult and juvenile fish because they are designed to emulate the flow and depth of a natural river, as the name suggests. To achieve this at Rodley Weir, the fish pass was 150m long, had an average slope of 0.688° and contained 12 low-head notched vertical steps, as well as gentle sloping landscaped banks and an area of backwater habitat (Figures 1 & 2). Nature reserve staff and local volunteers provide guided tours for members of the public around the fish pass. They also very helpfully collected data on water depth inside the pass to help in the analysis of fish movements.

Movements of fish through the pass were investigated for 15 months using passive integrated transponder (PIT) tags implanted into brown trout (under Home Office licence); the same technology vets use to 'chip' cats and dogs. Initial attempts were made to capture fish downstream of Rodley Weir in August 2013, but this was unsuccessful and was presumed to be the consequence of two pollution incidents in the preceding weeks.

Consequently, brown trout were captured from four sites upstream of Rodley Weir in October 2013 and translocated to 350m downstream of the weir. In addition, brown trout were captured from the 400-m long reach downstream of Rodley Weir in June 2014. Only fish >150mm were selected for tagging to ensure high tag retention and fish survival for the size of PIT tag used. Four tag detectors (A1-A4) located in the pass (Figure 3) recorded date, time and tag ID each time a PIT-tagged fish swam past. These data were then used to assess the proportion of tagged fish that approached, entered and moved through the pass. The influence of river flow, temperature, time of day and fish size on fish movements were also assessed.

Just over half the tagged brown trout were detected at the downstream entrance (A1) of the fish pass (51%, 57 of 111 fish). Undetected fish either spawned in the reach downstream of the weir, may have been sub-adult (smaller individuals) and hence did not perform a spawning migration, and/or fish may not have found the entrance to the pass. The majority of fish detected at the entrance of the bypass entered further (i.e. were detected on A2; 89%, 49 of 57 fish) and approximately

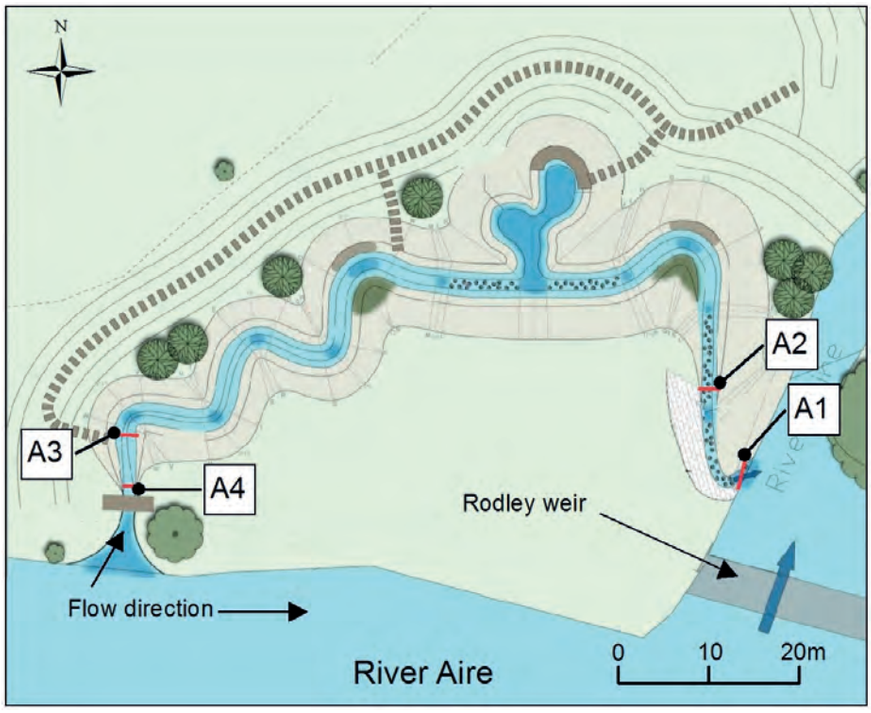


Figure 3. Location of monitoring equipment (A1-A4) in the nature-like bypass channel at Rodley Weir (Drawing courtesy of Yorkshire Water and ARUP).

three-quarters of the fish that entered the pass went on to ascend the pass and left in an upstream direction (last detected on A4; 78%, 38 of 49 fish).

The majority of fish quickly moved through the pass, ascending in less than an hour. The quickest time from entering the pass to completing an ascent was 13 minutes 27 seconds, with the slowest being 286 hours. Brown trout entered (Q97-Q2) and ascended (Q93-Q13) the pass over a wide range of flows, and were comparable to those targeted in the EA fish passage guidance documents. Specifically, fish should be able to ascend fish passes between flows that occur 95% and 10% of the time (Q95-Q10), where Q represents the percentage exceedance.

These results were especially encouraging as brown trout move during both high (e.g. spawning migration) and low (e.g. feeding and diurnal movements) flows. During the investigation, two fish were frequently detected entering and exiting the pass at dawn and dusk, respectively, and demonstrated how the nature-like bypass also provided habitat for feeding or sheltering.

In summary, based on our study at Rodley Weir, it would appear that nature-like bypass channels are an effective solution for improving connectivity for brown trout in rivers fragmented by weirs, while also providing habitat for fish to live in and undoubtedly many other unquantified benefits to wider biodiversity. Although habitats for all life stages of brown trout can be found downstream of the weir, the fish pass entrance location or dimensions could be altered in an attempt to improve attraction efficiency. For example, the fish pass entrance at Rodley Weir was perpendicular to the weir face, contrary to English, French and German guidance, which states it should be parallel to weir flow. That said, such modifications may be to the detriment of other efficiency metrics, such as to reduce the high entrance efficiency or narrow the range of flows during which are able to enter the pass.

More generally, this project has connected people from a range of backgrounds with the river, including government officials, a water company, engineers and academics during construction and monitoring, as well as politicians, fish telemetry practitioners and members of the public during open days. Here's hoping you, a Salmo Trutta reader, enjoyed the insight into fish passage on the River Aire, PIT telemetry and my PhD studies.

Jamie Dodd (J.Dodd@2009.hull.ac.uk) is a postgraduate researcher at University of Hull International Fisheries Institute (HIFI). Jamie and his supervisors, Dr Jonathan Bolland (@FishMigrationDr) and Professor Ian Cowx, have recently published some of the main findings of this study.

Dodd, J. R., Cowx, I. G. & Bolland, J. D. (2017). Efficiency of a nature-like bypass channel for restoring longitudinal connectivity for a river-resident population of brown trout. Journal of Environmental Management 204, 318-326..