Science Spot

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Research and Conservation Officer is my title at the WTT. It's a new position and while the Conservation Officer component is well defined and well exemplified by the sterling efforts of my longer established colleagues, the Research component is, perhaps counterintuitively, a tad nebulous. One aspect that Shaun Leonard and I discussed early on was that I should keep a weather eye on the current scientific literature so that I may pick up on any developments both directly and indirectly relevant to the work of the Trust... and decipher it in some cases to make it more accessible! I will share with you here a smattering of that knowledge, but I have been exploiting more immediate pathways, via the WTT webpages, sometimes as news items and occasionally in a little more depth in the WTT blog. In addition, taking immediacy to the extreme but severely trading off against depth, I 'tweet' science too; if that floats your boat then follow me: @ProfJGrey. Below, I have separated a few papers that have caught my attention into a number of topics.

HABITAT CHAT

A considerable amount of WTT conservation officer time is given over to the consideration of wood. Is it a suitable species for the locality? Is there enough of it or should there be more or less? Is it in the right place? How does one keep it there (and convince others that it will stay there)? Dead? Alive? How to maximise the benefits? So, you can imagine my slight trepidation when a perspective paper entitled *Wood placement in river restoration: fact, fiction, and future direction* popped up on my radar.

As a society, we have been removing wood from rivers for hundreds of years to improve navigation and to speed up water conveyance, but conversely, installing wood into rivers is also one of the oldest techniques of habitat improvement for the perceived benefit of fish stocks. Techniques have ranged from simply felling, pushing, or hauling trees from the nearby surrounding land into the active stream channel, to construction of highly engineered structures such as log weirs or engineered log-jams. In latter years, there has typically been a move away from the more engineered solutions to the placement of whole trees (including their root masses) or loose construction of log-jams in an attempt to emulate natural accumulations and delivery of large woody debris found historically in pristine systems.

The authors of the paper reel off some staggering facts regarding the number of projects (historically and currently) being implemented using various wood placement techniques. For example, in just one three-year period from 1933-1935, the United States Civilian Conservation Corps constructed more than 30,000 instream structures in more than 400 streams, and in a database comprising over 37,000 river restoration projects implemented in the United States between 1980-2005, nearly 6,000 of these were wood placement or other instream habitat improvement projects. One only has to look at the database of projects held by the River Restoration Centre to know how commonplace the technique is here in the UK, as it is throughout much of Europe, Japan, Australia and other parts of the world.

Yet, despite widespread uptake of the practical ideas and decades of research on wood in rivers, the addition of wood as a river restoration technique remains

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controversial, hence providing the raison d'être for the paper by Roni and colleagues. They reviewed the literature on both natural and placed wood to assess particular areas of continued debate. In terms of introducing wood, the key message to take away was that although a few studies had reported high structural failure rates of placed instream wood structures, most studies showed relatively low failure rates and that the placed wood remained stable for several years. Clearly the physical attributes of a system, whether the proposed siting position for the woody material is in an area of deposition or active erosion, and the fixing method are of paramount importance, as any WTT conservation officer will tell you! However, as with much science because of the way it is funded, long-term evaluations of placed wood are rare.

The majority of studies on wood introductions actually reported improvements in the physical habitat, for example by increasing pool frequency and hence habitat diversity, as well as providing cover and instream refugia. Another important message to relay was that those studies which failed to report any significant improvements in physical habitat were often in catchments where issues with sediment ingress, water quantity or quality had not been addressed. Finally, and thankfully, most evaluations of fish response to wood placement have shown positive responses for juvenile and adult salmonids (69% and 80% of studies, respectively), with results for non-salmonid fishes being equivocal. There is the usual caveat regarding time as relatively few studies have looked at long-term responses across the watershed-scale. Of those few, one of over 20 years duration found large and significant increases in coho salmon (*Oncorhynchus kisutch*) and trout numbers following wood placement. Cue outpouring of breath.

Just missing out on inclusion in this review, there was actually another longer-term analysis published last year by Pierce and colleagues, assessing the reconstruction of a low-gradient, groundwater-dominated stream in the Blackfoot Basin, Montana, specifically for brown trout habitat. The channel was reconfigured as well as variable amounts and configurations of coarse woody material placed along it, and livestock were excluded to promote the recovery of the bankside vegetation. To evaluate the response of wild trout, the abundance (number of trout per metre) and biomass of age 1+ trout were monitored for 15 years and compared with regional (reference) trends. In the reference reaches where no restoration work was undertaken, trout abundance was variable between years but over the full time-span of the study showed a decline; there was no detectable trend for trout biomass. However, following on from the restorative 'treatment', there was a significant increase in both abundance and biomass of trout where coarse woody material had been introduced. The authors make special note that even after 11 years of fisheries monitoring (from the completion of the restoration), their estimates of abundance and biomass showed no clear indication that wild trout populations had plateaued. Hence the full benefits of restoration work may take some considerable period (>10 years) to be realised.

In terms of a holistic approach to river restoration, introduction of woody material is not a panacea. It may well meet short-term, desirable physical and biological objectives of some restoration projects but it does not address a failure of the process that delivers wood to stream channels. Long-term and sustained amounts of natural wood in rivers and high quality fish habitat requires coupling wood introductions with the wider restoration of riparian habitat and upper catchments that are the natural sources of woody material. But that's another kettle of fish altogether.

Recipients of WTT advisory visits may often hear us harp on about creating a habitat mosaic; the life-cycle of the trout has different habitat requirements at different stages and if any particular important component is lacking, then it creates a 'bottleneck'. It is important to realise where (and when) these are likely to occur in order to maximise the population potential. In a field experiment, a group of Swedish scientists led by Höjesjö have examined the effects of habitat structural complexity on growth and abundance of juvenile brown trout; such complexity might confer better refuge from predation and flow, as well as better first feeding environments, so intuitively one might expect better fish growth if they have access to such. To standardise the complexity, they added artificial plastic plants and shredded plastic bags (which may explain why trout from the River Irwell are in such fine fettle!) For a short period after emergence from the egg, access to the complex habitat had a positive effect on the density, biomass and condition factor

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of young-of-year brown trout (compared to those maintained in simple, unstructured habitats) but the difference in density was not present six weeks later. The requirement for this type of habitat appears to be quite short-lived but nevertheless beneficial for increased survival of yearlings in early phases and consequently for the population structure of brown trout in natural streams.

Talking of refuge, spare a thought for any tiny tributaries within your network of waters, and I'm talking streams or trickles maybe only tens of metres long, less than a metre wide and only perhaps 5cm in depth; they may not even be permanently flowing. Some people might consider them ditches...They are often overlooked because they are not worth fishing, because the water is deemed too shallow for adult fish to spawn in, or because of misconceptions regarding flow and oxygen concentrations. Yet, such small tributaries may provide perfect nursery habitat with slow flows and low risk of predation for young-of-year fish, and when you tot up the number of such systems within a river network, they may constitute around 50% of the length. A study of tiny headwaters in Wisconsin, USA by Louison & Stelzer has highlighted that occupancy by trout is common and that while density is relatively low (generally less than one per m^2), higher densities are typically found in the slower flows. Hence, they advocate that tiny streams should not be overlooked, and that the condition and habitat in even the smallest should be managed and maintained appropriately to promote healthy trout populations. These aren't ditches to be dredged then!

P. Roni, T. Beechie, G. Pess, K. Hanson (2015) Wood placement in river restoration: fact, fiction, and future direction. Canadian Journal of Fisheries and Aquatic Sciences, Volume 72, pp466-478. DOI: 10.1139/cjfas-2014-0344

R. Pierce, C. Podner, L. Jones (2015) Long-term increases in trout abundance following channel reconstruction, instream wood placement, and livestock removal from a spring creek in the Blackfoot Basin, Montana. Transactions of the American Fisheries Society, Volume 144, pp184–195. DOI: 10.1080/00028487.2014.982261

J. Höjesjö, E. Gunve, T. Bohlin, J.I. Johnsson (2015) Addition of structural complexity – contrasting effect on juvenile brown trout in a natural stream. Ecology of Freshwater Fish Volume 24, pp608–615. DOI: 10.1111/eff.12174

M.J. Louison, R.S. Stelzer (2016) Use of first-order tributaries by brown trout (Salmo trutta) as nursery habitat in a cold water stream network. Ecology of Freshwater Fish, Volume 25, pp133–140. DOI: 10.1111/eff.12197

IN SPITE OF SPATES

The severe and unprecedented flooding experienced across northern England and Scotland towards the end of 2015 has prompted several fishy focussed discussions, particularly regarding the →

likely effect on trout eggs and fry survival. There has been considerable historical and much ongoing research determining the factors directly affecting these life-stages, not least, of course, because two of them, temperature and flow, are pertinent in light of climate change. For the UK and Ireland, heavily influenced by the Atlantic, the expected manifestation of climate change is for milder and wetter winters, with more precipitation falling as rain and less as snow, a decrease in the duration of ice-cover and increased frequency in extreme weather. This might be in conjunction with warmer summer and autumnal temperatures and potentially lower precipitation in these seasons too.

So, what does this mean for trout? Well, trout have to migrate to a chosen spawning site, cut redds and deposit eggs to be incubated in appropriately sized gravels, and the emergent fry have to find safe refuge, as I have just highlighted above. After a relatively dry summer and early autumn with above average temperatures (in north western England at least), there was eventually plenty of rain to allow fish to move to spawn throughout the majority of rivers; perhaps too much in some instances.

Storm Desmond broke over these shores in early December, well within the 'normal' trout spawning period. However, it should be noted that, according to the Met Office, the provisional UK mean temperature for December was 7.9°C, which is 4.1°C above the 1981-2010 long-term average, making it the warmest December in a series from 1910. November was also unseasonably warm at 8.2°C, 2.0°C above the 1981-2010 long-term average. Spawning time is thought to be temperature dependent because it influences the duration of embryonic development and, thereby, the timing of egg hatching. Larval trout growth and survival depend upon appropriate food resources and benign environmental conditions (amongst other things), meaning that fry survival is low if emergence from the gravels is either too early or too late. Hence, trout may not have spawned prior to Storm Desmond simply because up until that point it had been too warm (air temperature governs water temperature especially in spate rivers).

If they had spawned, then the catastrophic re-arrangement of the gravel, cobble and boulder substrates would have had severe consequences for egg survival. In many locations, prime spawning gravels have been redistributed across floodplains, and left high and dry to desiccate. I was chatting to colleagues at Lancaster University regarding their ongoing research in the Eden catchment and their data show that the biofilm (algal, bacterial and detrital matrix) was so efficiently scoured from the stone surfaces in December that it was barely detectable.

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However, there is a silver lining to this storm cloud. There is plenty of evidence demonstrating the negative impacts of the timing, magnitude and duration of extreme flow conditions, and the rate of change in discharge between hatching and emergence times, on trout survival and recruitment. But trout populations are also regulated by what ecologists call density-dependence, meaning that if only a few trout emerged and survived the worst of the spates, then those few should do better in the following year because they have less competitors within their age class for resources. A modelling study by Kanno and colleagues, using a 15-year record of brook trout abundance from 72 sites in Shenandoah National Park, Virginia, USA, has revealed that different population 'vital rates' (i.e. key parameters contributing to population success) responded differently to weather and site-specific conditions. Of these vital rates, young-of-year survival was most strongly affected by spring temperature and per-capita recruitment by winter precipitation. Overall, high winter precipitation had the strongest negative effects on brook trout populations; their modelling simulations showed that brook trout abundance could be greatly reduced under constant high winter precipitation, reflecting the impacts of gravel-scouring on survival of eggs and emergent larvae. However, they predicted that the majority of brook trout populations would persist if high winter precipitation occurred only intermittently (in less than three out of every five years) due to density-dependent recruitment. If we can extrapolate such results to brown trout in our spate rivers, then the likes of the Eden populations should be resilient for a while yet, provided other stressors like habitat degradation can be staved off. Just another hint that the practical, instream work of the Trust is so vital to buffer trout populations against extreme events.

Y. Kanno, B.H. Letcher, N.P. Hitt, D.A. Boughton, J.E.B. Wofford, E.F. Zipking (2015) Seasonal weather patterns drive population vital rates and persistence in a stream fish. Global Change Biology, Volume 21, pp1856–1870. DOI: 10.1111/gcb.12837

STOCKING FILLER

Thankfully, it is extremely rare in the UK that we have to consider the complete reintroduction of wild brown trout to a river, or indeed any other imperilled native freshwater fish, and long may it remain so. However, further afield it is becoming an increasingly important conservation tool amidst persistent anthropogenic pressures and new threats related to climate change. This has prompted a review of the current literature (some 260 published case studies) by Cochran-Biederman and colleagues, to identify and assess the predictors of reintroduction outcome, and devise recommendations for managers attempting future native fish reintroductions. What became abundantly clear was that inadequately addressing the initial cause of decline of a particular fish species was the best predictor of reintroduction failure. Those variables associated with habitat such as water quality and prey availability were also good predictors of reintroduction outcomes, then followed by variables associated with stocking such as the genetic diversity of stock source.

That message surfaced in a very different study comparing 16 Estonian rivers that were monitored for the management and conservation of our beloved brown trout. The work was recently published in *Conservation Biology* by Ozerov and colleagues. They carefully considered the worth of introducing gravel substrate into rivers to create spawning habitat. The study found that while trout readily used such gravels relatively quickly after introduction, the actual success of the trout progeny was still limited by the wider environmental conditions of the river in question. In essence, it is possible to boost juvenile trout numbers in already productive rivers where all the other conditions such as water quality, habitat, and food are favourable. However, in rivers with sub-optimal conditions such as high sediment load and poor flow, the addition of extra spawning habitat may not immediately increase the numbers of juveniles.

While WTT occasionally promotes the installation of spawning gravels, it is of little long-term benefit if it will be clogged by silt from upstream after the next spate, or there is no suitable juvenile habitat nearby for the fry to move to. Hence, to promote wild brown trout populations or to nudge them further from the brink of imperilment, WTT COs always try to address the root of problems they come across on advisory visits rather than simply advocating 'sticking plaster' solutions.

To finish off, I'd like to quickly return to a second component of the study by Ozerov in the 16 Estonian trout streams and which was based upon some genetic work of the trout populations. The authors found only a very weak relationship between the effective number of breeders and the numbers of juveniles produced. Hence, many factors influence juvenile trout abundance; it isn't simply the case that more breeding adults equals more small trout. In some instances, quite high numbers of effective breeders were found alongside low numbers of juveniles indicating that low habitat quality or lack of suitable spawning substrate was a bottleneck to population recruitment. However, in others, it was apparent that only a few effective breeders were contributing a very large number of progeny to the population overall. Trout populations in such systems will be markedly affected by indiscriminate removal of even a one or two of those disproportionately important breeding fish. So, while I am probably preaching to the converted on these pages, catch and release would certainly help to safeguard their future.

J.L. Cochran-Biederman, K.E. Wyman, W.E. French, G.L. Loppnow (2015) Identifying correlates of success and failure of native freshwater fish reintroductions. Conservation Biology, Volume 29, pp175–186. DOI: 10.1111/cobi.12374

M. Ozerov, T. Jürgenstein, T. Aykanat, A. Vasemägi (2015) Use of sibling relationship reconstruction to complement traditional monitoring in fisheries management and conservation of brown trout. Conservation Biology, Volume 29, pp1164–1175. DOI: 10.1111/cobi.12480

Keep an eye on the WTT Blog between issues of Salmo trutta for science snippets at: http://www.wildtrout.org/wttblog