Agenda item 5.2
For information

Council

CNL (15)43

Maintaining and improving river connectivity: the current position and experience in England

CNL(15)43

Maintaining and improving river connectivity: the current position and experience in England

This paper provides an overview of the scale of the historic legacy of obstructions to fish passage and how an innovative approach is being taken to identify priority obstructions and improve river connectivity. It then outlines, how in response to the recent growth in hydropower in England, hydropower guidance has been developed to ensure that migratory fish are protected and that river connectivity is maintained or improved.

Historic legacy of obstructions to fish passage in England and Wales

The Environment Agency has established a geographic database of obstructions across England and Wales. It identified 26,000 obstructions (18,000 of which are man-made) on a river network length of 300,000km, which equates to one obstruction every 11.5km (see Figure 1). These range from large dams, which may have been built for navigation and/or milling, to smaller structures, for example, for irrigating water meadows. However, on some rivers the frequency of obstructions can be much greater. For example, on the River Yealm, in south Devon, which is a short moorland spate river, there are over 30 man-made obstructions to migration over a distance of ~18km.

The establishment of a geographic database allows for a much more systematic approach to improving river connectivity and integrating this information into river basin planning including: Water Framework Directive River Basin Plans (and supporting Sea Trout and Salmon Catchment Summaries), Flood Risk Management Plans and Eel Management Plans.

Figure 1. 26,000 obstructions across England & Wales

Obstructions have a fundamental impact on both river connectivity and natural river processes. Under the Environment Agency's most recent assessment of reasons for not achieving 'Good Ecological Status' under the Water Framework Directive, physical modifications including obstructions were identified as the most significant factor.

For salmon, these physical modifications can inhibit adults reaching valuable spawning habitat, impact on the survival of smolts migrating to sea, degrade critical salmon habitat and affect water quality and river flows. Obstruction to fish passage is recognised as one of the critical issues affecting England's salmon populations and is a priority for action in England's salmon strategy: *Better sea trout and salmon fisheries 2008 - 2021*.

A ~7lb salmon attempts to leap Padiham Weir on the River Calder, a tributary of the River Ribble in North West England – November 2006

Improving river connectivity

Through the first cycle of the River Bain Management Planning (2009 - 2015) under the EU Water Framework Directive[1], improving river connectivity and addressing obstructions to fish passage was highlighted as a priority to prevent deterioration and improve ecological status. Through considerable effort by the Environment Agency, Natural England, the Department for Environment, Food and Rural Affairs (Defra), Rivers and Wildlife Trust, fisheries interests, landowners and community groups working together, between 2009 - 2014, more than £22 million was invested in addressing 229 obstructions across England and Wales (Figure 2). This was, in many ways, made possible through Defra's River Improvement and Catchment Restoration Funding programmes.

The improvements that have been made to river connectivity have included schemes from sea to source, ranging from installing tidal flaps and fish friendly side-hung gates at the tidal limit to removing obstructions completely or installing a wide range of fish passage easements and passes to the benefit of multiple species (see Figure 2).

[1] http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm

In improving river connectivity, the hierarchy in decision making that the Environment Agency follows is: remove the obstruction> construct a natural bypass> modify the obstruction to make it passable> install a fish pass. Wherever possible the emphasis is on working with natural processes and maximizing benefits for multiple species and habitats, whilst not compromising flood risk management requirements.

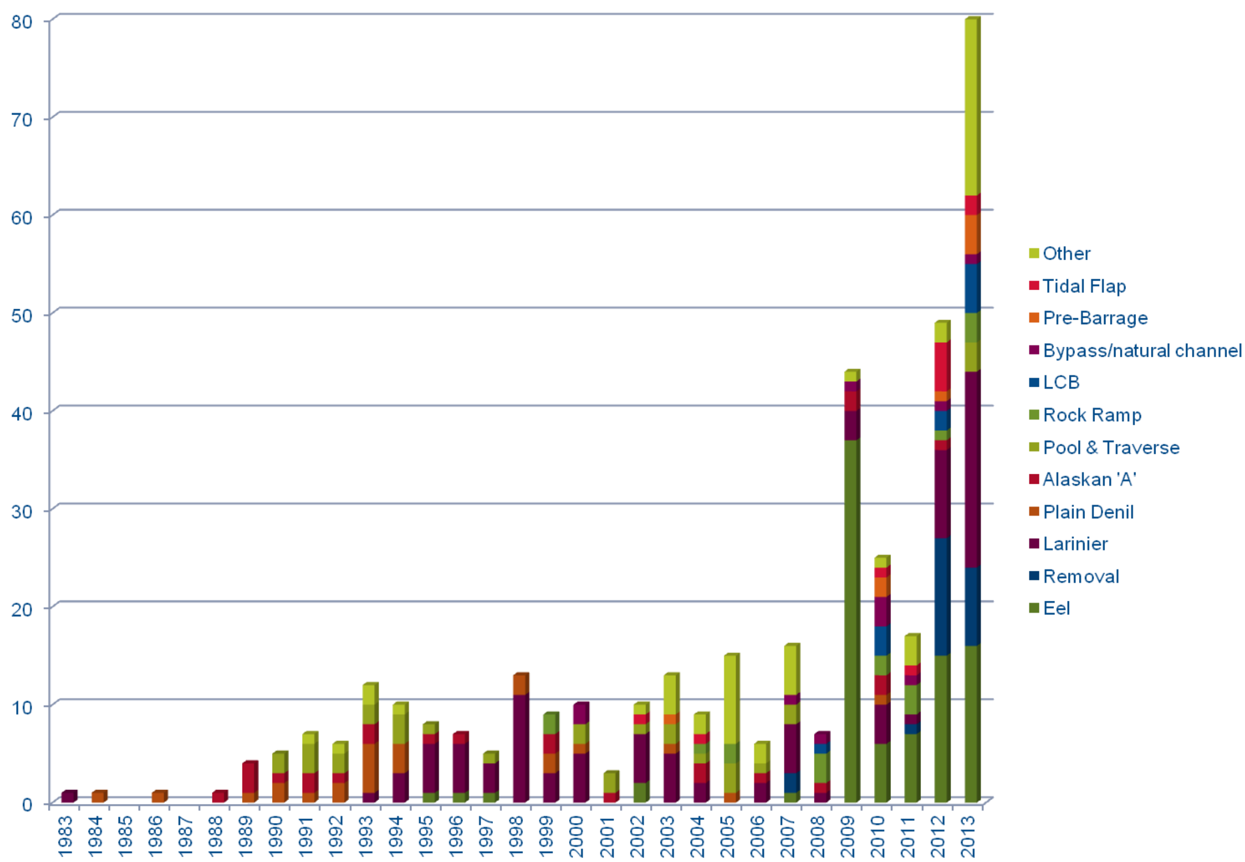


Figure 2. Fish passage improvement schemes across England and Wales 1983 - 2013

For England's 42 principal salmon rivers, 63 fish passes and easements were built between 2009 and 2014, which has improved access to 3,700 km of river, see Figure 3. This is the equivalent of the distance from London to the west coast of Greenland. Eight of these 63 fish passes and easements were linked to hydropower schemes.[2]

[2] These have all been built since 2012. This information may not have been recorded for earlier sites. Environment Agency National Fish Pass Database

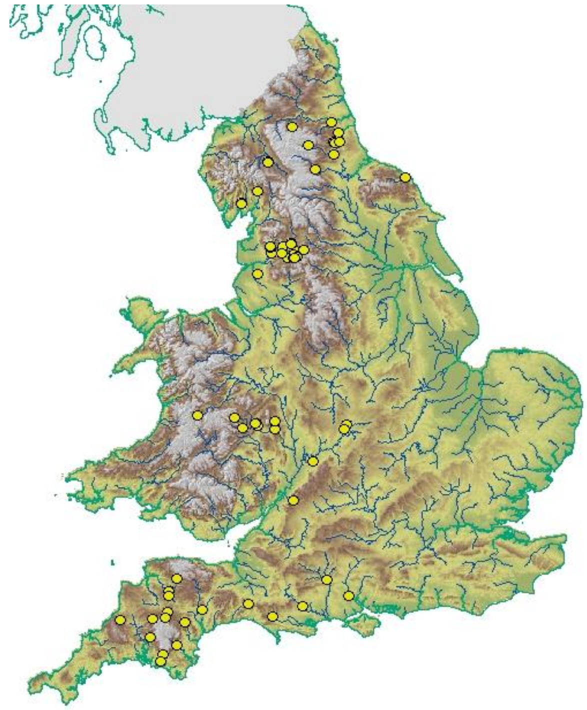
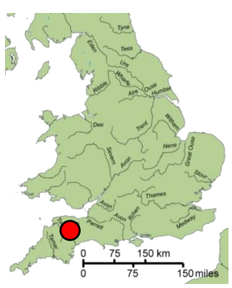


Figure 3. Location of 63 fish passes and easements on England's 42 principal salmon rivers constructed between 2009 and 2014.
(Includes River Severn catchment which extends into Wales)

Case study (a): River Mole Head Weir Natural Fish Pass[3]



The River Mole is an important sub-catchment of the River Taw in North Devon and provides the primary spawning and nursery area for Atlantic salmon and sea trout in the Taw catchment. The River Taw is one of England's 42 principal salmon rivers and is currently assessed as being 'probably at risk' (failing to meet or exceed its salmon conservation limit in 4 years out of 5)[4].

Head Weir was constructed in c.1840 to feed an abstraction to Head Mill and was the most downstream obstruction on the River Mole. Though a Denil fish pass had been constructed in 1991/92, when the weir crest was raised by the then owners, there were a number of factors that made it ineffective. Head Weir was identified as an issue in the River Taw Salmon Action Plan (2003) and was seen as contributing towards the water body failing to reach Good Ecological Status under the Water Framework Directive.

In 2007, the Environment Agency surveyed seven weirs on the Taw system and all were judged to impede fish access upstream. Head Weir was amongst the worst. This led to the concept of the Westcountry River Trust's Taw Access over Weirs (TAW) Project, which was supported by

---

[3]European Centre for River Restoration – Case Study: River Mole Head Weir Replacement (pdf)
[4] ICES Annual Assessment of Salmon Stocks and Fisheries in England and Wales, 2014

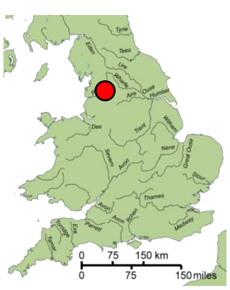
the River Taw Fisheries Association, Defra, the Environment Agency, the Association of Rivers Trusts and the Interreg Atlantic Area AARC Project.

In 2009, the Environment Agency funded the design and in 2010 Westcountry Rivers Trust secured funding from Defra's River Improvement Fund. A natural fish pass was chosen as it would provide fish passage for a variety of fish species, operate over a wide range of flows, require minimal maintenance and was aesthetically in keeping with the location.

Head Weir before and after construction of a natural fish pass

The work was undertaken by the Environment Agency and completed at the end of 2010, at a cost of £325,000. As a consequence of the project, over 40kms of spawning habitat has been made accessible, which is estimated to have the potential of producing up to 2,000 additional salmon smolts each year. An immediate benefit was seen with many salmon being observed upstream of the fish pass the following year.

Case study (b): River Calder Padiham Weir removal[5]



The River Calder is a tributary of the River Ribble in North West England and has numerous weirs and dams associated with its industrial past. The River Ribble is one of England's 42 principal salmon rivers and is currently assessed as being 'at risk' (failing to meet or exceed its salmon conservation limit in 4 years out of 5).

Padiham Weir was built in the 1950s to provide water to a now demolished power station. At 1.85m it was the largest weir on the River Calder and created a total barrier to all fish migration.

[5] UK River Restoration Centre, Manual of River Restoration Techniques 12.4 Weir lower and rock ramp construction Padiham Weir River Calder (pdf)

In 2010, the Environment Agency and Ribble Rivers Trust led a £400,000 project to lower the weir and build a rock ramp in partnership with local fishing clubs to improve river connectivity for multiple fish species.

Padiham Weir before and during construction

Since this project was completed, further measures have been taken by the Environment Agency and Ribble Rivers Trust to address more obstructions upstream which have included full weir removal, rock ramps, Alaskan A fish passes, Larinier fish passes and pre-barrages. Salmon and sea trout are now able to migrate from the sea to very near to the source of the formative tributaries of the River Calder for the first time in 150 years thanks to a lot of hard work and partnership working.

In 2012 and 2013, salmon kelts and carcasses were observed above Padiham and in 2014, for the first time, salmon fry were found on the River Calder by the Environment Agency during its electric fishing surveys.

Identifying priority obstructions

To help optimise the environmental outcomes from improving river connectivity, a matrix has been established to identify super critical and high priority obstructions that seeks to deliver for multiple species (salmonids, coarse fish and eels) and multiple legislative drivers (Habitats Directive, Water Framework Directive and the Salmon and Freshwater Fisheries Act 1975). For England’s salmon rivers, 72 obstructions have been identified through this process (see Figure 4). Complementing this, catchment-based priority obstructions will be identified for England’s principal salmon rivers in partnership with local stakeholders as part of a process of updating Sea Trout and Salmon Catchment Summaries. To help with this, the Environment Agency is developing a phone-based APP that will enable people to provide information on obstructions in a way that links to the geographic database, which is otherwise known as ‘crowd sourcing’ data.

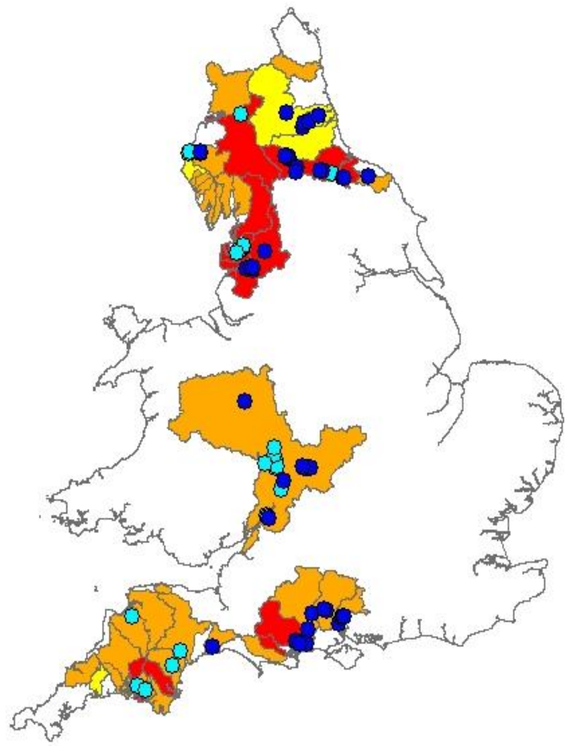


Figure 4. 72 super critical (dark blue) and high priority (light blue) obstructions on England's 42 principal salmon catchments. (Includes River Severn catchment which extends into Wales) The colours indicate the present state of salmon stocks (2014)[4]: red = 'at risk'; orange = 'probably at risk'; yellow = 'probably not at risk'; green = 'not at risk'

Hydropower development in England

In 2009, the UK signed up to a legal obligation to meet 15% of its energy demand from renewable sources by 2020[6] and hydropower is seen as having the potential to make a small but useful contribution to this target. English hydropower currently generates 0.03% of the electricity consumed in the UK[7]. To encourage development of renewable energy schemes, such as hydropower, a feed-in tariff scheme was introduced. The prospective expansion of hydropower caused concern, especially amongst fisheries interests, about the potential effect of hydropower schemes on fish populations including salmon.

The majority of hydropower development in England is run-of-river schemes and the average size is less than 100kW.

The Environment Agency has permitted around 350 schemes in the last 40 years and 223 since the 2009 introduction of subsidy support through the Government feed-in tariff[8]. However, not all of these have been built. It is currently estimated that about 220 hydropower schemes are operating across England and Wales (Environment Agency, *personal communication*). The

[6] DECC (2011) National Renewable Energy Action Plan for the UK. Article 4 of the Renewable Energy Directive 2009/28/EC.
[7] DECC (2013) Electricity generation and supply figures for Scotland, Wales, Northern Ireland and England, 2004 to 2012 Spreadsheet].
[8] Figures up to December 2013.

Environment Agency receives about 30 - 40 applications for new developments each year. Figure 5 (below) shows the distribution of hydropower schemes across England and Wales.

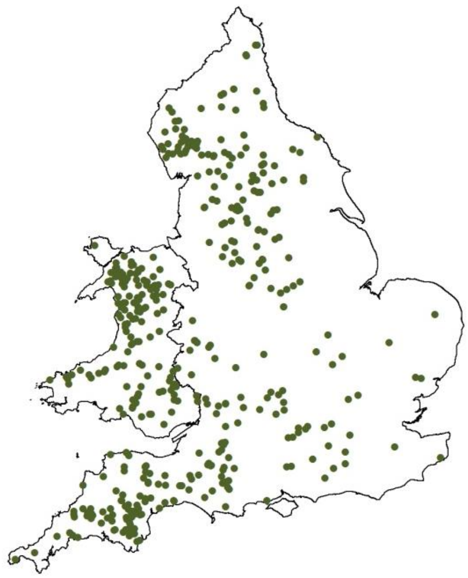


Figure 5. Location of permitted hydropower schemes across England and Wales based on Environment Agency data up to December 2013
(not all schemes may have been built or may not still be operational)

Guidance

The Environment Agency is a key regulator for hydropower development in England and is responsible for addressing effects on the aquatic environment and fisheries.

Undertaking works in rivers and impounding and abstracting water are subject to permitting by the Environment Agency. In determining permits, the Environment Agency is required to address impacts: on water flow and availability and on other permitted water users; on fish and fisheries; on protected wildlife and habitats; and on the management of flood risk.

In meeting its duties, the Environment Agency has developed guidance in consultation with the hydropower industry and fisheries interest groups.

Good practice guidance was first issued in 2009. This has subsequently been updated to include high-head schemes and particularly take on board concerns associated with the management of flows. The Environment Agency's *Guidance on run-of-river hydropower development* was published in January 2014[9].

Environmental protection safeguards

[9] https://www.gov.uk/government/publications/good-practice-guidelines-to-the-environment-agency-hydropower-handbook

To ensure that the environment is protected, the Environment Agency has issued detailed technical guidance on: flow and abstraction management; geomorphology (including weir pools);

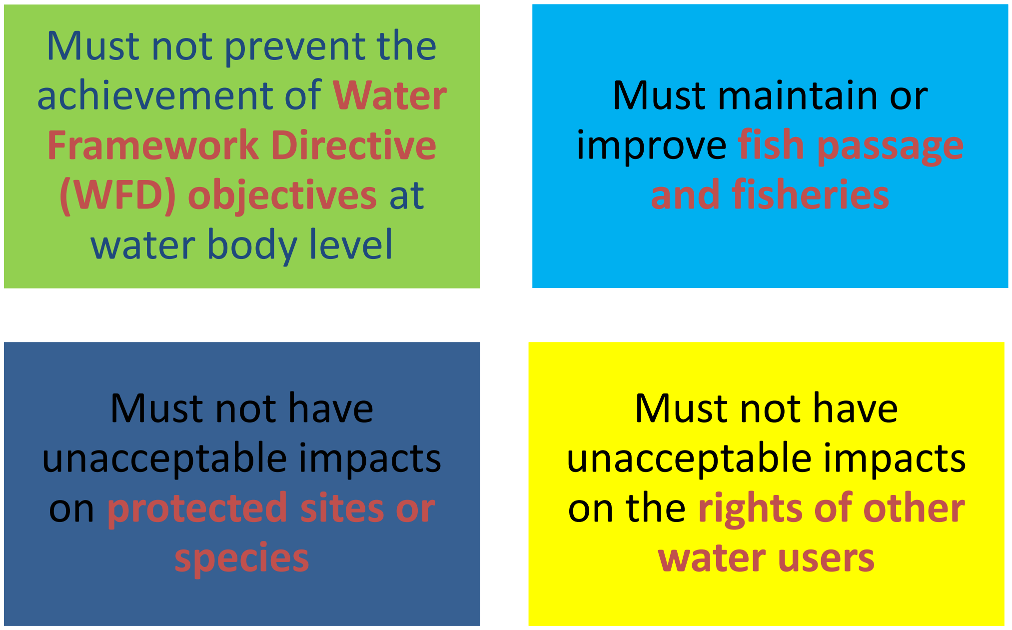


Figure 6. Four tests to ensure that hydropower developments do not have unacceptable impacts on flows

fish screening requirements; fish passage; Water Framework Directive, nature conservation and heritage; and flood risk.[9] To protect flows and maintain and improve river connectivity, four tests have been developed to ensure that hydropower developments do not have unacceptable impacts (see Figure 6).

On a number of rivers, hydropower developments have been accompanied by new fish passes that have improved the migration pathways for salmon and other fish. For example, on the River Tavy at Abbey Weir and Hill Bridge on the eastern edge of the Dartmoor National Park in South West England, the Environment Agency secured improvements in prescribed flows, fish screening and fish passage at three abstractions used for hydropower schemes operated by South West Water. The total investment was over £1 million and it is estimated that the fish screens save hundreds of smolts every year.

Several pieces of targeted research have been commissioned by the Environment Agency examining screening efficiency[10], weir pools[11] and the potential for cumulative effects[12] and the Environment Agency and Cefas (Centre of Ecology, Fisheries and Aquaculture Science) are working with the Game and Wildlife Conservation Trust to investigate possible impacts of Archimedes hydropower schemes on the behaviour of emigrating salmon and sea trout smolts.

[10] To be published
[11] To be published
[12] Environment Agency (January 2015) Cumulative effects of hydropower schemes of fish migration and populations – Report SC10078 [available via www.gov.uk]

Hill Bridge hydropower intake on the River Tavy in South West England - protected river flows, fish screening and improved fish passage saves hundreds of smolts every year.

Case study (c): Romney Weir hydropower scheme on the River Thames

The Romney Weir hydropower scheme on the River Thames was built on an existing weir, which provides for navigation and flood risk management. Although there was an historic Denil fish pass on the weir it was only suitable for upstream passage of salmon, sea trout and large coarse fish. As part of the hydropower scheme, the developers were required to install a multi-species Larinier fish pass. It was positioned adjacent to the river bank and co-located with the outflow from the turbines to maximize attractant flow and optimise upstream fish migration. To protect the integrity of the ecologically important weir pool, which provides fish spawning and holding habitat, a flow split was agreed across all of the competing requirements for flow: navigation lock, side channels, ecologically important habitat, fish pass, hydropower turbine etc. to meet the needs of the environment whilst providing for power generation. A Computational Fluid Dynamics investigation into the impact of the hydropower scheme on the weir pool suggested little impact to water velocities and depth, Figure 7 [13].

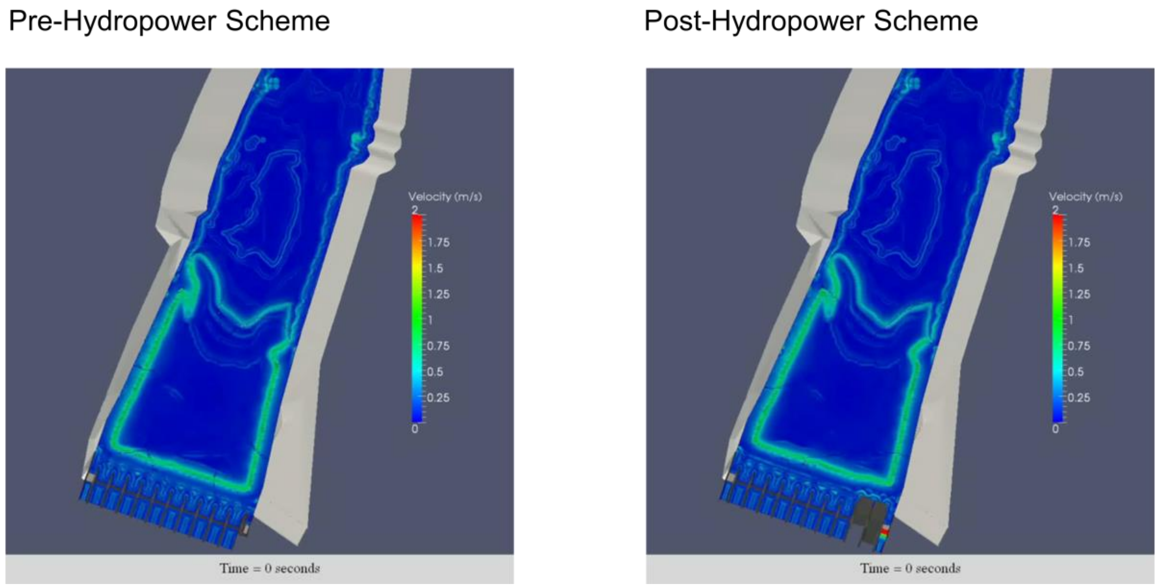


Figure 7. Romney hydropower scheme - pre and post water velocities in the ecologically important weir pool

Potential cumulative effects

With an increasing number of hydropower schemes and a concern about whether the effect of individual schemes could be cumulative, the Environment Agency commissioned a literature review and the development of a model to assess the impact of multiple hydropower schemes on salmon.

The literature review showed that multiple schemes have the potential to increase effects, but most of the studies were on overseas sites which were much larger than those typical in England.

The model which tested various scenarios of between 1 to 6 hydropower schemes using hypothetical data based on the Northumberland River Coquet, indicated a range of effects from +18% to -12% of the numbers expected of returning adult salmon. The study found that the variation in effect was highly dependent on the assumed passability of existing barriers, the efficiency of any constructed fish pass, and the location of the scheme on the river with downstream-sited schemes having the potential to cause larger positive or negative effects. Positive effects were always driven by the inclusion of improved fish passage at individual

[13] Environment Agency (2013) Romney Weir Hydropower CFD Modeling – report by Arup

schemes. The study highlights the importance of careful design of schemes and implementation of mitigating measures at individual sites.

Potential effects of Archimedes screw turbines on salmon smolts

The Environment Agency and Cefas are working with the Game and Wildlife Conservation Trust to investigate the effect of a small low-head hydropower scheme on the behaviour of emigrating wild salmon and sea trout smolts on the River Frome in Dorset.

Acoustic transmitters surgically implanted into the peritoneal cavity and submersible acoustic receivers positioned at strategic positions around an Archimedes hydropower scheme and throughout the associated river catchment are being used to monitor the behaviour of emigrating smolts to where the estuary meets the sea. PIT tagged salmon smolts are also being released upstream of the mill to assess impacts. A similar acoustic study is currently being undertaken at a hydropower scheme on the River Ribble. At present the numbers of tracked smolts has been low so the results are inconclusive. The research is ongoing.

Conclusions

Maintaining and improving river connectivity is a critical issue to safeguard England's salmon populations. On England's principal salmon rivers, the Environment Agency has identified 72 super critical and high priority obstructions, which when addressed would open up access to a significant amount of river habitat, providing the potential for a substantial increase in smolt output.

There is continuing interest in hydropower development in English rivers. Through engagement and discussion with hydropower developers along with environmental and fisheries interests, guidance is in place to enable development while addressing environmental and fisheries issues. On a number of rivers, hydropower developments have been accompanied by new fish passes that have improved the migration pathways for salmon and other fish. Targeted research has been commissioned to assess effects and impacts of hydropower developments.