Detailed Submission by the Angling Trust in Response to the Public Consultation on Flow Protection Aspects of the Review of Good Practice Guidelines

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Introduction

The Angling Trust is the representative body for angling and fisheries interests in England . It is recognised as such by the Environment Agency and as the National Governing Body of the sport of angling by Sport England. It is a formal consultee of Defra on all matters affecting angling, fisheries and the related environment.

Angling is enjoyed by more than 3 million people from all sectors of society in England and Wales. It has a value to the economy of £3.5 billion and employs more than 37,000 people directly, with many other jobs depending on its indirect economic benefits. Fishing rights are privately owned and leased by angling clubs and landowners and are in total worth several billion pounds. The value of these property rights on rivers is highly dependent on the quality of the water environment.

75% of waterbodies are failing to achieve good ecological status or potential, as required by the Water Framework Directive. Of these failures, the majority are failing because of poor fish populations. This Directive also requires member states to avoid any deterioration in the ecological status of water bodies. Many rivers are failing to meet their conservation targets for salmon as set out in Salmon Action Plans. Eel populations have declined across Europe by 95% in recent years. The status of many Special Areas of Conservation and Sites of Special Scientific Interest on rivers is threatened by environmental degradation.

This submission has been prepared in conjunction with the conservation charity Salmon and Trout Association. The joint authors are specialists in the field of fisheries and environmental management and have considerable experience of dealing with hydropower at all levels from individual schemes to the development of national policy.

Detailed Comments

1. Abstractions for hydropower are regulated and charged by the Environment Agency as non-consumptive. Viewed at a catchment scale that may be valid, but for any stretch of river whose flow is depleted this is not the case. Therefore, flow allocation for hydropower should be based on the same principles as for consumptive abstractions and any variation fully justified.

2. The peer-reviewed scientific literature widely recognises that flow variability, both within and between years, is a key factor in maintaining and sustaining water ecosystems. All elements of the flow cycle are important to the ecology of a riverine system: ie the quantity, timing, duration, frequency and quality of flows[1]. Low flows are required for juvenile habitat; maintenance

[1] Acreman M.C. & Ferguson A.J.D. 2009. *Environmental flows and the WFD*. Freshwater Biology 55 (1): 32-48. And many others.

flows and “freshets” to stimulate migration for spawning and dispersal; small floods to distribute river sediments and connect river and floodplain habitats and large floods to maintain channel structure.

3. Although the Water Framework Directive does not specify environmental flows it is accepted that ecologically appropriate hydrological regimes are necessary to achieve good ecological status. This has been confirmed in writing by the European Commission.

4. No evidence has been presented to justify the four options presented by the Agency in this consultation, not even hydrographs. The regimes proposing a Hands-off Flow until a maximum abstraction of 1 or 1.3 times the mean flow do not allow the required variability and have been shown to be damaging to resident fish populations and invertebrates. They have also been shown to have adverse impacts on fish migration. SNIFFER report WFD48 *Development of Environmental Standards (Water Resources)* concludes that fixed compensation flows do not constitute an environmental standard.

5. The only option for which there is evidence is Option 3, which complies with CAMS/EFI standards recommended by UK TAG and which is applied to current consumptive abstractions. An issue arises, however, where a river is currently at, or nearing, its abstraction limit. Clearly, in such cases, the imposition of yet further flow reductions on the potential depleted reach would be unacceptable.

6. It is argued in the consultation document that for on-weir schemes, where water is returned at the toe of the weir, that there is no depleted reach other than the weir structure itself. This is a misleading oversimplification as the existing flow regime into the weirpool will be completely altered and the energy removed, by diverting a large proportion of the flow through a turbine. Weirpools, particularly on highly impounded low-gradient rivers, form very important diverse habitats, essential for rheophilic species to spawn. The same protection should apply as for other schemes – that a protective regime is applied unless the developer can demonstrate that their proposals will not cause an unacceptable impact. Weirpools are also very important for angling and any significant amendment to the flow regime is highly likely to impact on the quality of that angling and the amenity and financial value of fishing rights.

7. There is no reason why the same regime should not be applied to high head schemes. First and second order watercourses contribute to maintaining hydrologic connectivity – transport of matter, energy and organisms – and ecosystem integrity of the catchment. Impoundments and creation of long flow depleted reaches “modifies fluxes between uplands and downstream river segments and eliminates distinctive habitats”.[2]

8. The Agency is legally required to meet the objectives of the Water Framework Directive, in addition to its statutory duty to ‘maintain, improve and develop fisheries’ – a duty first imposed by Parliament in the 1923 Salmon and Freshwater Fisheries Act and confirmed in all subsequent amending primary legislation. Therefore, the GPG guidelines must start from an environmentally protective baseline, where any deviation from the standards can only be licensed if the developer can show that such modifications will not significantly impact the environment. The onus must be on the developer to provide the evidence to deviate from the standards not the publically funded Environment Agency or other interested parties. Option 1 and 2 do not start from this baseline and the focus would still remain on the Agency to provide evidence of impact which, set against a background of increasing Government cuts, is not practical or acceptable.

Summary of Evidence for Sustainable Flows

The Angling Trust and Salmon & Trout Association have based their responses on the evidence of both personal experience and a comprehensive body of peer-reviewed literature.

Abstractions for hydropower are treated by EA’s Water Resources as non-consumptive. On a catchment basis this may be true; but for any depleted reach – whether a stretch of river or a weirpool – the effect is the same as for consumptive abstractions, and therefore should be treated as such when considering the allowed take for run-of-river hydropower. Setting inappropriate flows has been shown to affect both the ecology of the depleted reach itself and fish migration.

The matrix of allowable flows in the current GPG set a “hands-off” amount – equivalent to low summer flows – and then allows a turbine take of any additional flow up to the mean flow or thereabouts. We can find no published evidence to justify this approach, indeed Tennant (1976) argued that a residual flow recommendation based on maintenance of low flow conditions was like “prescribing a person’s all-time worst health condition as a recommended level for a portion of his future well being.” The SNIFFER WFD48 report in 2005 *Development of Environmental Standards (Water Resources)* concluded that fixed compensation flows do not constitute an environmental standard. As long ago as the early 1960’s Baxter (1961) argued that this traditional method of setting compensation flow was unrelated to biological need, and that there should be a variable compensation flow regime based on the seasonal needs of the fish and of the river. More recently Petts

[2] Freeman M.C., Pringle C.M. and Jackson C.R. 2007. *Hydrologic connectivity and the contribution of stream headwaters to ecological integrity and regional scales.* Journal of the American Water Resources Association 43(1): 5-14

*et a*l (1996) expressed the view that a single minimum flow for a river reach can have negative consequences for the instream fauna and there should be a regime that mimics natural flow fluctuations. Poff *et al* (1997, 2003), Acreman and Dunbar (2004) and many others argued that the concept that as long as a minimum "critical" flow is maintained all will be well, is false and that all elements of a flow regime are important, including floods, medium and low flows. Poff and Zimmerman (2010) reviewed 165 papers concerning the ecological response to altered flow regimes; whilst macroinvertebrates showed mixed responses, fish abundance, diversity and demographic rates consistently declined in response to both elevated and decreased flow magnitude. They concluded that flow alteration is associated with ecological change and that the risk of ecological change increases with increasing magnitude of flow alteration. Arthington *et al*. (2006) argue that simplistic, static, environmental flow "rules", rather than flow variability, are misguided and will ultimately contribute to further degradation of river ecosystems.

Hydrological connectivity is the water-mediated transfer of matter, energy and organisms within or between elements of the hydrologic cycle (Pringle, 2003). Freeman *et al*. (2007) emphasise that, cumulatively, headwater streams contribute to maintaining hydrologic connectivity and ecosystem integrity at catchment scales. Altering them, by channelisation, diversion through pipes leaving a grossly depleted reach and impoundment modifies fluxes between uplands and downstream river segments and eliminates distinctive habitats. Therefore headwater streams must be considered as carefully as low order streams, especially regarding flows in depleted reaches and the construction of impoundments.

Exley (2006) described a marked environmental impact from prolonged periods of low flows on the River Itchen, a high baseflow river.

Furthermore, there is evidence from throughout Europe that the effect on fisheries of such flow regimes results in substantial decline of fish biomass and density, and changes to population structures, with proportionally greater impact on small streams (Lusk *et al.* 1995, 1997), with rheophilic species particularly impacted including brown trout, grayling, chub, barbel and nase. Kubecka *et al* (1997a, 1997b) assessed 23 bypass (separate mill channel) hydro schemes in the Czech Republic. They compared fish populations of natural sections upstream of hydropower schemes and the depleted reach downstream and related it to the ratio of mean flow to turbine capacity. The streams had mean flows varying from 0.08 to 4.1 cumecs, and the residual flows were between the equivalent to between Q_{93} and $Q_{97.}$ They demonstrated that where the turbine capacity was greater than half the mean flow, fish biomass was reduced by between 66% and 97% of that found in the unaffected reaches. There was also a notable downward succession from large-bodied species (adult brown trout, chub, dace, grayling) towards small-bodied (trout fry, minnow, bullhead, stone loach, gudgeon). The study concluded all schemes should be equipped with an efficient fish pass that enable migrations even in low-flow conditions, and that schemes built on small rivers caused the most damage. This was in accord with Jowett (1997) who also noted that small rivers are more at risk from low flows than large ones and require a higher proportion of average flow to maintain environmental protection.

Similar findings have been have been made for trout and grayling populations in Slovakia (Muzik 1995), Belgium (Ovidio *et al* 2008), Spain (Almodovar and Nicola 1999) and the French Pyrenees (Baran *et al* 1995). Lamouroux *et al* (2006) showed that when the residual flow in a depleted reach on the River Rhone was increased tenfold there was a two- to fourfold increase in relative abundance of fish species that prefer fast-flowing and / or deep microhabitats.

Royal Haskoning (2009) interpreted data relating to pre- and post-scheme monitoring of a depleted reach and a control site following the construction of a small hydropower scheme on the River Frome. It concluded that the macroinvertebrates, using BWMP, ASPT and taxa number, had markedly decreased in the depleted reach, particularly for those species preferring moderate to fast flows. The aquatic macrophytes increased in both number and species abundance in both reaches, but the Mean Trophic Rank score for the depleted reach suggested that it was moving further towards a eutrophic state. The fish populations showed a general increase in abundance of most species at both sampling sites, but that the increase was most marked in the depleted reach. However, this increase was largely due to the abundance of roach; a eurytopic species. Rheophilic species, such as dace, barbel, chub, and brown trout showed an increase in the control reach, but were either absent or showed no increase in the depleted reach.

Clearly, such changes in the resident fish population would cause a significant deterioration of the recreational angling in the deprived reach. Irrespective of any change to migratory salmonid movement, which is discussed in the next section, Baxter (1961) also described how low flows can reduce their “catchability”.

Upstream migration and spawning present a considerable energetic cost to migratory salmonids, with estimates ranging between 60 & 70 % of body reserves (Jonsson *et al*.1997). Significant extra stresses, such as finding and then negotiating fish passes, multiple attempts to leap impoundments, diversion into routes with no fish passage, may leave them more susceptible to predation, poaching or stress induced diseases, or they may simply fail to reach spawning grounds (Brett 1957, Mathers *et al*. 2002).

Some obstructions may be passable without a specific facility, possibly only during periods of high flow or at a particular range of flows. If the flow over the obstruction is reduced either by diverting water through a different channel or through a turbine on the impoundment, fish passage may be reduced or even eliminated. In such a circumstance the installation of a hydropower scheme should not be permitted unless a suitable provision for fish passage facility is made.

When adult salmonids migrating upstream approach a channel convergence, such as a hydropower effluent channel, which has no directional clues other than flow, fish will inevitably be influenced by the greater volume and, possibly, velocity (Banks

1969, Jensen *et al.* 1986, Bagliniere *et al.* 1990 and Jonsson 1991). If the channel with the greater flow has no provision for fish passage this will result in delay or even blockage to migration. In a number of experiments at hydro schemes in Sweden, Thorstad *et al.* (2003, 2005) used radio tags to track upstream migrating salmon approaching hydropower schemes with residual flow reaches. When the residual flow was just 10% of the turbine flow, salmon were invariably attracted to the turbine channel and remained there for up to 71 days even though there was no physical barrier preventing them accessing the bypass channel. Fish that eventually passed into the residual reach distributed themselves throughout its length, but 60% actually returned to the turbine channel. None completed its migration, despite there being adequate fish passes at the head of the depleted reach. Small and short artificial freshets (increases in flow in the residual reach) did not seem to stimulate migration.

Karppinen *et al.* (2002) noted a similar effect on salmon in a Finnish river, as did Arnekliev and Kraabol (1996) with migratory brown trout in a Swedish river. This behaviour corresponds with the monitoring by Solomon *et al.* (1999) of radio-tagged adult salmon in 6 rivers in SW England which assessed the salmon's propensity to migrate in relation to the Q_{95} flow. They found that although a flow of Q_{95} was sufficient to stimulate migration in the lower reaches of a river, a flow of several times Q_{95} was necessary further upstream. Therefore hydropower schemes further upstream in a catchment may need to leave a proportionally higher residual flow in a depleted reach, greatly impacting its economic viability.

The Central and Regional Fisheries Boards of Ireland considered the issue of flow allocation when producing guidelines for hydropower development (Anon. 2007). These stipulate that for rivers within which diadromous migration takes place, the flow in the bypassed channel shall be 50% of the upstream flow or 12.5% of the mean flow, whichever is the greater. However, even a 50% division of flow may not be sufficient to prevent migration delay or be sufficient to maintain the ecology of the depleted reach (Murphy 2000).

Kibel (2007) monitored, using underwater video cameras, adult salmon and sea trout approaching, through a short channel, the bottom of an Archimedean screw turbine on the River Dart. Despite the turbine capacity of 1.7 m^3s^{-1} being small compared to the average river flow of over 11 m^3s^{-1}, salmon and migratory trout were nevertheless attracted to the tailrace. This was possibly due to the high water velocity in the channel of 2.5 ms^{-1}. Although the fish only remained in the vicinity of the turbine for an average of just 8 minutes before re-entering the main river, it is not known if they immediately continued their upstream migration or remained in the vicinity of the turbine channel outflow for a period of time. Therefore if the flow of water in one channel is constrained in relation to the other, fish may still be influenced by the higher velocity. Where possible, the exit from mill channel to the main river should be modified to reduce the water velocity, and consideration given to creating a deeper channel on the opposite side to the turbine effluent to guide fish to the correct migration route.

Hydropower schemes constructed directly on an impoundment, avoiding a depleted reach, are often considered preferable, otherwise all channels should include provision for fish passage. A much greater flow from a turbine can readily distract fish; Rivinoja *et al.* (2001) showed that only 26% of salmon found a route beyond a turbine to the fish pass, and Linlokken (1993) examined 8 fish passes and found that grayling and brown trout were attracted to turbine outflows rather than lower fish pass flows. Construction of passes must therefore be aware of best practice in construction, positioning and flows.

Cowx and Welcomme (1998) present the criteria that fish passes should meet, including the importance of an appropriate flow attracting fish to the pass entrance. Larinier (2002) discusses the best positioning for situations where a turbine is on a weir and the importance of the outflow being situated next to that of the fish pass. Lucas and Baras (2001) described a situation where two Denil fish passes were positioned on the left and right sides of a long spillway. These worked well until a small hydro plant was built between them, following which rheophilic species were attracted to the high turbine flow and failed to find the fish passes. A fish pass discharge must be able to compete with other flows (Clay 1995, Larinier 1998, Laine *et al.* 2002) and should take about 10% of the maximum turbine flow, although there is some argument for reducing normal pass flow targets if the hydropower outflow is co-located and can be said to be augmenting attraction without unduly competing (Larinier 2008, G. Armstrong, personal communication). The persistence of salmon in attempting to ascend the greatest flow was described by Sedgewick (1962) in an incident where an electric screen, to deter fish, was used in a turbine tailrace on the River Shannon. Salmon were attracted towards the turbine flow, were stunned, recovered and continually tried again, but failed to be attracted to the residual flow channel.

Impoundments disrupt a river's natural course, divert flows, alter water temperatures and chemical quality, redirect river channels, transform floodplains, disrupt continuity of sediments and animals and alter the biological composition (Bednarek, 2001; American Rivers, 2002). They have impacted on fish populations and diversity for, in some cases, centuries and continue to do so by disrupting one or more stages of their life cycle either directly or through changes in their habitat. Connectivity of habitats is regarded as critical to the integrity of aquatic ecosystems and their communities of fishes and other biota (Jungwirth *et al*., 2000; Schiemer, 2000). Where possible, the emphasis should be on removing barriers, not perpetuating their damaging presence for the next fifty or more years by allowing the unsustainable construction of a hydropower scheme.

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