River Wye Salmon Action Plan

Bold and Urgent Action: A way forward

A Proposal from the Wye Salmon Association
December 2019

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1. Executive Summary

The River Wye was one of Britain's foremost wild Atlantic salmon rivers, at its peak over 50,000 salmon a year were estimated to be running the river, many returning adults supporting stocks in other estuarine rivers such as the Severn, Usk and Taff. Today in annual returns Natural Resources Wales (NRW) consistently report low salmon numbers returning from their oceanic phase, risking natural regeneration, runs now having declined to an estimated 2,000 to 3,000 and angling catches down 94% from their peak in 1967.

The plight of the Atlantic salmon is a recognised barometer of overall water quality and the health of the environment. This is an important indicator species in global waters, potentially showing whether or not rivers and oceans are clean, healthy and supportive of life. An indicator species supporting the Wye SAC status.

Wye Salmon Association (WSA), an organisation formed from owners, anglers & gillies with a mission of protecting, improving & sustaining salmon populations, believes a state of emergency exists with respect to salmon numbers in the river Wye and Severn Estuary.

The proposal contained herein seeks high level commitment from NRW and the Environment Agency (EA) in the development of a broad angling community partnership approach to managing the recovery of the river Wye salmon stocks based on the assumption changes in Atlantic salmon numbers in the river Wye are directly related to or even mainly due to 'in river' issues. The current NRW Salmon Action Plan (SAP) in place in Wales is overdue a revision. The Wye Local Fishery Group (WLFG) representing a wide range of fisheries, angling and conservation interests is proposed as the vehicle to oversee the management of such an initiative. A bold and urgent initiative to change the focus of recovery from task oriented to results driven.

The key elements in this proposal are:

- a co-ordinated, focused and results driven approach
- focus on improving water quality
- continued habitat improvement
- removal of barriers
- removal of sources of pollution
- tighter control on levels of predation
- review of fishing regulations
- juvenile enhancement and monitoring programme

The Wye Local Fisheries Group [WLFG], a non-statutory group established by NRW as a communication link with representative fisheries interests and to facilitate partnership working, traditionally has a strong involvement in and varied experience of the river, its fish and its problems. Suitably re-constituted, empowered and provided with appropriate technical resources the WLFG could create the momentum needed and the focus required to drive results. Its role would be to ensure implementation of all elements of the proposal, continuously monitoring progress and evaluating effectiveness of approach. It would reassess interventions, set priorities and report progress towards the aim of delivering agreed targets.

This proposal recognises that today there is a pressing need for salmon populations and the environment they live in to be the subject of a dedicated process of management in order to achieve recruitment optimisation and deliver both conservation targets and provide for fishery purposes.

The role of juvenile enhancement is considered by WSA to be fundamental to the future of salmon stocks in the river Wye. Providing essential, urgent and a robust, much needed boost to stocks whilst some of the in river initiatives take inevitable slow routes to maturity. If the decline of the Atlantic salmon in the Wye is not proven directly related to or even mainly due to 'in river' issues, juvenile enhancement might also provide a long term strategic contingency to protect salmon stocks from factors beyond our control, defeating our efforts and putting at risk the river Wye SAC status.

2. Background

The Wye Salmon Association (WSA), an organisation formed in 2011 from owners, anglers & gillies with a mission of protecting, improving & sustaining salmon populations, believes a state of emergency exists with respect to salmon numbers in the River Wye and Severn Estuary.

After two centuries of a slow and steady decline that coincided, both geographically and chronologically, with human industrial development, wild Atlantic salmon populations have plummeted precipitously over the past three decades. However, any assumption the decline of the Atlantic salmon in the Wye as seen in fig1 is directly related to or even mainly due to habitat destruction as a result of industrialisation and population growth would ignore other contributing factors and in particular that of Greenland Net Fisheries.

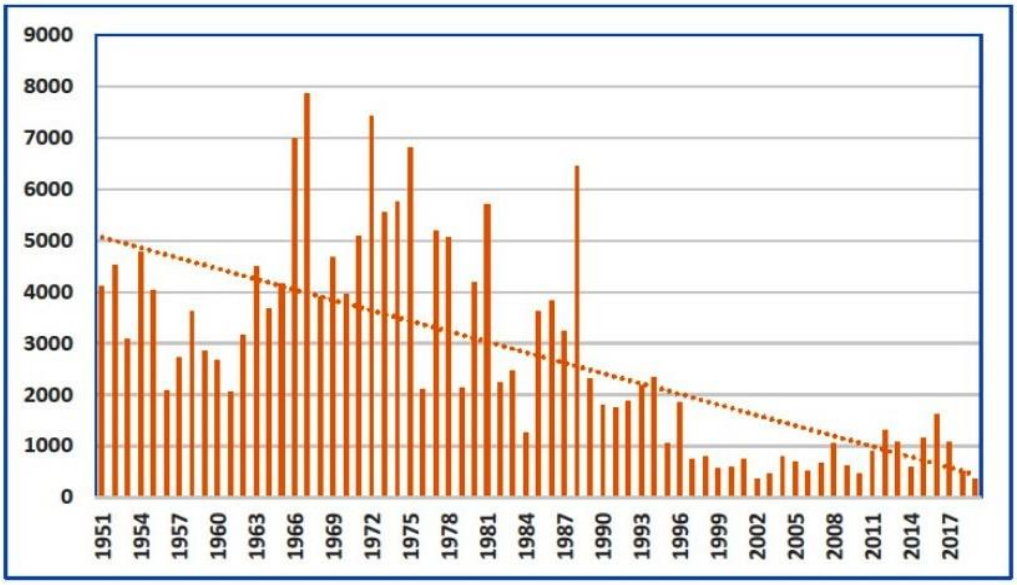


Figure 1: The River Wye Rod Catches 1951 to 2019

Salmon catches in the entire North Atlantic fell by more than 80% between 1970 and the end of the 20th century. Today they stand at the lowest levels in known history, with wild Atlantic salmon completely extirpated from much of their original range and hanging by a thread in many other locations. Atlantic salmon populations are known to be comparatively healthy in only four countries – Norway, Ireland, Iceland and Russia.

The decline in catches was matched by a similar decline of Greenland feeding salmon as represented by the graph in fig 2. In 1967 Lord Balfour was reported in Hansard confirming the export, from Greenland, of Atlantic salmon had risen from 2 metric tonnes in 1957 (approx 880 5lb non maturing salmon) to 1400 metric tonnes (aprox 616,000 5lb non maturing salmon) in 1964. This net fishery went on to record 2,700 metric tonnes in 1971 (approx 1,188,000 5lb non maturing salmon). It can see again in fig2, this level of catches was unsustainable and despite quotas being set from the early 1980's on the reported catch rarely met the quota, due to lack of fish stock.

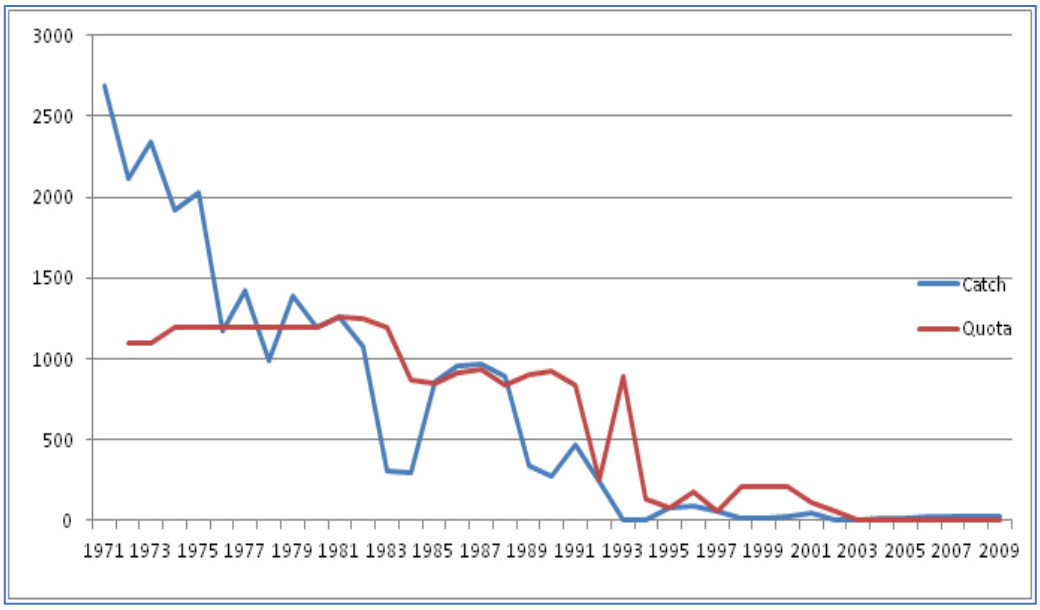


Figure 2: Greenland Net Fishery Catches

A paper [Enberg 2009] studying the implications of netting fisheries-induced evolution for stock rebuilding and recovery reports the most obvious effect of net fishing is a reduction in population abundance and biomass. Classic theory of fishing suggests rapid population recovery if fishing is ceased, but in practice recovery rates have been much slower than expected, and in some cases the expected recovery has not taken place at all [Hutchings 2000a]. Fishing [netting] changes the demographic composition of a stock toward a dominance of younger and smaller fish [those that escape due to net size]. A truncated age and size structure may have consequences for population dynamics and has been shown to reduce reproductive potential. The extents to which overfishing affects stock biomass, population structure, phenotypic plasticity, adaptive evolution, or ecosystem structure have important implications for recovery. In particular, the failure of some fish stocks to recover after their collapse. Fig 3 shows a typical timescale for stock recovery

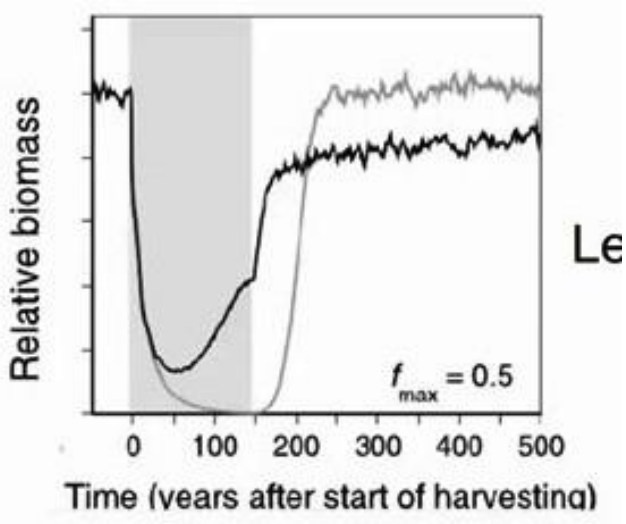


Figure 3: Greenland Net Fishery Stock Recovery

You may wonder why this Greenland Net Fishery doesn't seem to affect the East Coast of Scotland rivers. They appear to migrate on completely different routes and some may never go to Greenland at all, remaining in the Norwegian Sea to feed.

The Atlantic Salmon is a recognised barometer of overall water quality and the health of the environment. It is an important indicator species in global waters, potentially showing whether or not rivers and oceans are clean, healthy and supportive of life. The salmons anadromous nature exposes the species to human pressures in both freshwater and marine environments and over long periods, exacerbating its decline.

The Wye was one of Britain's foremost Salmon rivers, at its peak a suggested 50,000 salmon a year ran the river, with many returning adults supporting stocks in other estuarine rivers such as the Severn and the Usk. In its annual fisheries returns NRW consistently reports low salmon numbers returning from their oceanic phase, compromising natural regeneration and risking extinction of the species as it is unable to sustain a viable breeding population. The river Wye runs have now declined to an estimated 2,000 to 3,000 and salmon rod catches on the Wye have been falling for more than 30 years. In 2019 the third lowest number [340], since 1940, has been reported, a 94% reduction from its peak in 1967.
During the last century, the freshwater habitat of Atlantic salmon was significantly impacted by industrial development as well as agricultural and forestry practices. The changes in land and water believed to result in effects ranging from a dramatic decline of salmon in many river systems, to outright extinction in others.

NRW has a duty, defined in the Environment (Wales) Act 2016, to sustainably manage natural resources. It undertakes initiatives to deliver fish stock improvements, considering the whole catchment when identifying and addressing fisheries' issues; working with partners to carry out remedial work for their customers, specifically anglers, fisheries and landowners.

Although natural factors may negatively impact the population dynamics of salmon, the most severe 'in river' impacts have been caused by human activities such as water pollution, disruption of natural watersheds, forestry and agricultural activities. These were added to by overfishing in Greenland Net Fisheries, climate change, sea survival (suggested as having declined from 20% to 2% over three decades) and the impact of the significant growth of populations of fish-eating birds (FEBs) such as cormorants and goosanders visiting the river to feed and/or breed.

The major habitat requirement for adult salmon is accessible spawning area. The physical habitat requirements and the relative proportion of habitat required may vary in quantity and quality and influence the size of the population in a given river. In general terms, the biophysical habitat requirements of salmon include well-oxygenated water, absence of organic and inorganic pollution, fine gravel bottom for spawning, combined with suitable juvenile nursery sections and cover for migrating adults (WWF May 2001).
During the incubation of ova and the emergence of fry, adequate flow of water through the gravel is especially important. Water depth, velocity, and stream-bed cover are the principal physical variables for juvenile salmon, the availability of suitable habitat is often considered the limiting factor in fry densities.
In general, juvenile salmon occupy shallow, fast-flowing water, combined with overhead cover provided by surface turbulence. In summer, fry occupy shallower and faster flowing sections of river. Gravel composition is of vital importance to eggs and alevins. Consequently, gravel extraction and river

engineering work upstream may alter flood dynamics and natural gravel compositions downstream with catastrophic results.

Erosion and siltation can be induced by forestry, agriculture, mining and other human activity involving the use of heavy equipment. Most natural spawning river gravels hold concentrations of suspended sand, silt and clay. Another effect of increased concentrations of suspended matter is the clogging of the gills, which ultimately can be lethal. Foraging may also be reduced if such conditions become protracted.

The effect of water temperature changes on salmonids is a significant factor in their survival. Temperature influences both the period of incubation of eggs and thus the time of emergence, as well as the subsequent development rate of juveniles.

The NRW 'Wye Juvenile Salmonid Summary of 2018' reported salmon fry and parr densities showing statistically significant declines over 1985 to 2018. Although fry populations recovered somewhat in 2017, 2018 showed the second lowest numbers since 2007. Poor parr results continued 2018 saw numbers doubling from 2017, though numbers are still very low. The average catchment density for salmon fry was far lower than the 5-year average and the numbers seen in 2017. The lower number of salmon fry did not equate to lower salmon parr populations, with average density doubled to 3.0 per $100m^2$. However, the average density for 2018 was still the third lowest in the last 10 years.
The 2019 report showed Salmon fry (0+) densities continuing to decline. The Dernol recording the lowest salmon fry density since 1992, dropping from grade A (excellent) to grade C. The normally excellent Marteg and Edw sites also declined in fry densities, the Marteg dropping a grade to B (good). Consistently over the years, salmon parr (>0+) densities have been less than good at the Wye survey sites. Parr classifciations dropped off a little in 2019, no site being graded better than C (fair), the best site last year, the Marteg, notably dropping from a good status to fair.

It is interesting at this point to compare river Tweed numbers. River Wye 5yr average Fry density is 57.5 per $100m^2$, currently river Tweed is circa 80 per $100m^2$. River Wye 5yr average Parr density is 2.9 per $100m^2$, currently river Tweed is circa 20 per $100m^2$.

Pollution of freshwater is perhaps the single most significant 'in river' factor in the decline of Atlantic salmon populations. Most pollution comes from domestic, agricultural or industrial wastes and can be lethal to fish. Pollution remains most problematic in rivers close to densely populated areas. Historically, increased urbanisation and industrialisation have reduced or exterminated the Atlantic salmon populations in many rivers. Many of the impacts that exist today (raw sewage discharge, industrial effluents, discharged hydrocarbons, elevated concentrations of phosphates and nitrogen) were first observed more than 100 years ago and have continued, or worsened.

Urbanisation, agriculture and other human activities impacting riverbanks all serve to reduce or denude riparian vegetation. The soil-binding function of streamside plant life is thereby lost, and riverbank instability becomes evident. Ultimately, the riverbanks may be undercut and collapse into the river with detrimental effect. In addition to siltation damage to spawning areas, invertebrate densities may be reduced, with a corresponding reduction in habitat quality. The widening of channels by such bank collapses can reduce water velocity leading to insufficient flow through the spawning beds. Loss of streamside vegetation can also serve to increase mean summer water temperatures, especially in the upper reaches, and to reduce the natural supply of invertebrate food sources into the ecosystem.
Man-made structures and obstacles (weirs, pipe bridges, dams, bridge footings) or natural (waterfalls and timber blockages, for example) can all form insurmountable barriers for the

upstream spawning migration of adult salmon and for down-stream juvenile migration. In many cases, this factor is considered another major cause of Atlantic salmon population decline.

River restoration is no simple matter. The challenges are multi- faceted, involving various inter-related factors. The benefits of restoration depend on the pressure on returning salmon in the estuarine and marine environment. The success or otherwise of projects can only be properly assessed after the entire life cycle of the salmon has been completed, usually requiring about 10 years.

The Wye and Usk Foundation (WUF), is an organisation formed in the mid 1990s, the origin of which was in support of and as the executive arm of the now defunct Wye Salmon Fishery Owners Association (WSFOA). It has been, and continues to be, instrumental in tackling many projects on the river Wye, restoring and protecting riparian habitat, enabling free access for fish migration, improving water quality and quantity. Since 2003 the WUF has also been working to correct the damaging effects of acidity in the upper Wye and Irfon catchments. A Government funded study estimated that 62km of the upper Wye and Irfon plus their tributaries were significantly affected by acidification. Putting limestone powder in bogs at the very source of streams (hydrological source liming) was not only effective at neutralising acidity but also long lasting. However, there simply weren't enough bogs left to introduce the required amount of calcium. Initial results of another method of introducing limestone to the catchment, ie direct dosing of random sand-sized particles to what are termed "first order streams" (those that have no tributaries) proved its sustainability, provided dosing was repeated annually.

Salmon stocking as a means of restoring salmon stocks, has taken place, in one form or another, since Darwin's time (1850s) Stocking of the Wye, funded by Dwr Cymru Welsh Water, was carried out from 1974 to 2014 as mitigation for the spawning areas lost as a result of the Elan Reservoir construction. Detailed stocking records exist for that period with the exception of the years from 1996 to 2003, where perhaps due to the difficulties in the operation of the owner operated Green Bottom hatchery, there was little or no stocking, or at least none on record at NRW. In 2012, WSA, supported by fishery owners, operated a series of 'Semi Natural Rearing' (SNR) ponds aimed at significantly improving the efficacy of this stocking activity. The programme, supported by NRW, was run in line with a paper (Taylor 1998) written by Dr John Taylor, the NRW Fisheries & Aquaculture Technical Specialist. However, a policy decision made by NRW in 2015 banned juvenile stocking across Wales and both mitigation stocking and SNR project were forced to cease operation. Little or no data is available, nor was indeed collected to verify the performance of these stockings. Anecdotal evidence would suggest the decline in stocks has gathered pace since this decision.

Under Ministerial direction, principal rivers in England & Wales produce Salmon Action Plans (SAPs) and are required to assess and report on compliance with Conservation Limits (CLs) in the form of egg deposition. The SAP and its assessment of performance are aimed at helping to ensure that the NRW has appropriate fisheries management measures in place. Conservation Limits (CLs) are set based on estimates of the salmon producing capacity of individual rivers. Compliance assessment involves (i) producing estimates (from rod catches or more direct methods e.g. use of traps or fish counters) of the numbers of salmon returning each year and their likely egg contribution and (ii) undertaking formal statistical assessment of compliance status against the CL. The latter procedure is designed to achieve the 'management objective' ie that stocks meet or exceed their CL four years out of five, on average.

Individual river salmon populations are evaluated annually against stock conservation limits (CLs) and management targets (MTs) in line with the requirements of the International Council of the Exploration of the Sea (ICES) and the North Atlantic Salmon Conservation Organisation (NASCO). This conservation limit (CL) offers scientists and managers the ability to assess the status of populations and to enable them to evaluate and manage exploitation appropriately. The conservation limit (CL) is the point below which the population should never fall and must be considered the minimum effective size to maintain genetic diversity. The CL is set as an egg deposition target. However, this is based on the available spawning habitat and the assumption that everything is pristine and optimum. We believe egg deposition targets do not consider adequately pollution, siltation, acid rain, FEB pressure, etc, and in our opinion the CL target is set too low.

Egg deposition estimate for the Wye in 2018 was 21.15×10^6 or 55% of CL. The 'management objective' is that the Wye should meet or exceed its CLs in at least four years out of five. The Wye has only exceeded its CL in one out of the last fifteen years. The latest (2018) compliance assessment classifies the Wye as 'probably at risk' and projected to remain so in 2023. The Conservation Limit for the Wye is 38.57×10^6 and the Management Target (MT) 49.31×10^6.
The Wye has not achieved its MT in the last fifteen years and likely has not done so since 1997.

3. Wye Salmon Association Proposal

Forecasts suggest no immediate resolution to the failure of salmon numbers in existing plans. We need ‘bold and urgent action’, so says a senior NRW Officer!

A high level commitment from NRW is required to assist in developing a broad angling community partnership approach to managing the recovery of the river Wye salmon stocks. WSA believes the Wye Local Fishery Group (WLFG) representing a wide range of fisheries, angling and conservation interests could be the vehicle for such an approach.

This proposal targets the enhancement of juvenile salmon levels offering a clear focus; a bold and urgent initiative to change the orientation of current recovery actions from task to result-driven; a process able to create momentum based on the goal of delivering conservation and fishery exploitable levels of salmon numbers. The plan offers a positive, multi-faceted solution to population restoration, building on much of what exists today, without fixating on any one idea, simply focused on the delivery of salmon numbers. There is a pressing need for salmon populations and the environment they live in to be the subject of a dedicated process of management in order to achieve recruitment optimisation and deliver both conservation targets and provide for fishery purposes.

Fundamental to the future of salmon stocks in the river Wye is the need to provide an urgent, robust, much needed boost to stocks whilst this process takes place. maturity. There is also a need to provide a long-term strategic contingency in the event factors beyond our control, such as sea survival and climate change, defeat our efforts and risk the river Wye SAC status.
The key elements in the proposal are;

3.1 A coordinated and focused approach to salmon stock management

Opinions on solutions to recovering salmon numbers on the Wye have become increasingly polarized as catches have continued to decline. A paper discussing (on the River Wye) ‘a critical

discourse analysis and lessons for management of social conflict over Atlantic salmon (Salmo salar) conservation' (Harrison 2019) reported the emergence of a consensus oriented Middle Ground Coalition reflecting action organised around the shared interests of its stakeholders. River Wye managers should encourage this coalition by allowing them to lead affected stakeholders into becoming active planning and policy making participants, pursuing interventions to perceived problems, rather than outright solutions, and collaborative strategies that allow competing stakeholder groups to work toward shared realities and achieve multiple objectives. A productive way forward in mitigating or avoiding future conflicts.

Six key constraint areas are categorised, most are already being addressed in some form or another. However, in order to maximise focus and effort the nominated overseeing team will be required to carry out gap analysis and assessment of all current initiatives and interventions in the six constraints, prioritising and target setting in support of the overall objective of conservation and fishery exploitable levels of salmon numbers. We offer some ideas for serious consideration in each of the six constraints in the next section.

The schematic management process proposal (fig 4 below) begins with a key acceptance of the need for intervention and resolution to the decline in salmon stocks. It encourages involvement of all stakeholders in its functioning, providing for continuous monitoring of activities to evaluate effectiveness of approach and assesses and reassesses interventions and priorities using an adaptive approach

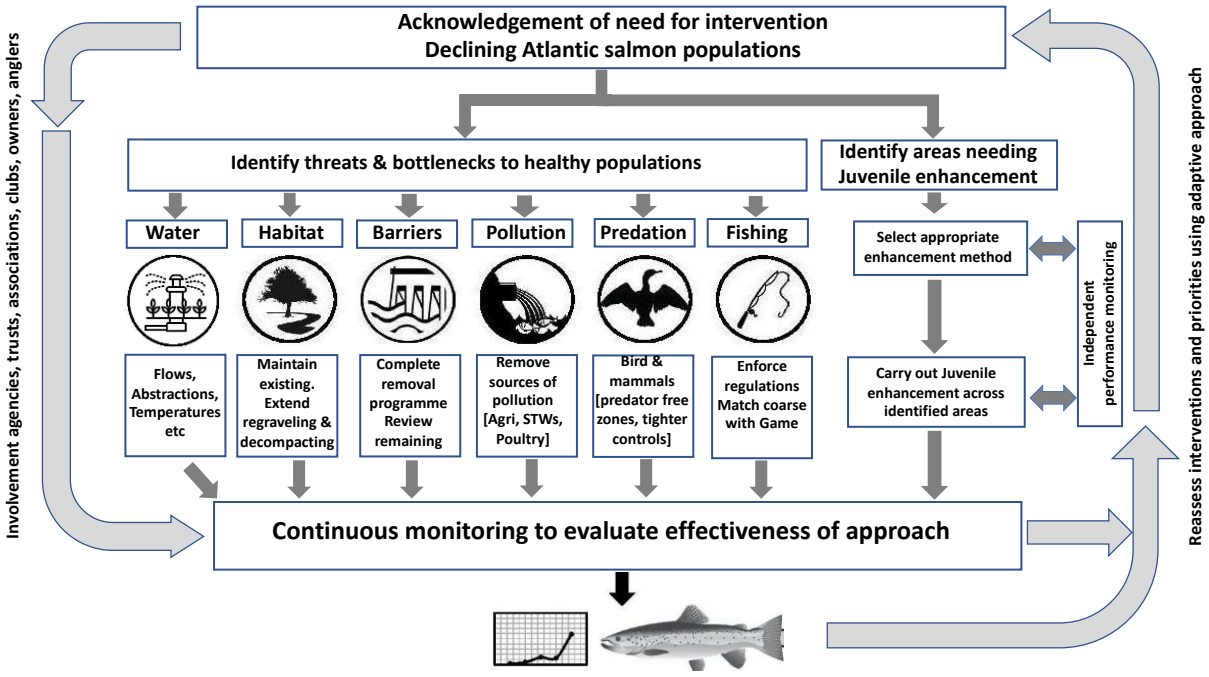


Figure 4: Salmon Action Plan - Schematic of Management Process

Salmon stocks and the environment in which they live should be managed to optimise recruitment for both conservation and fisheries purposes. Reference points exist to provide both scientists and managers with the ability to assess the status of fish numbers, but also to enable them to evaluate and manage exploitation appropriately. The Conservation limit (CL) is the point below which the stock level should never fall and is the minimum effective population size to maintain genetic diversity. Management target (MT) is the stock level set to achieve a desired outcome: The Management

target should exceed the conservation limit. A revised Management Target (MT) for egg deposition should be used in future planning, set to take into account the current lack of optimum conditions and the desire to achieve an outcome in terms of population and fishery exploitation. Considering current survival rates we propose a MT of $59.77x10^6$, which equates to a rod catch result of circa 2,500, an objective target for the Wye, that would be seen by most of those in the angling community as acceptable, given current circumstances.

WSA proposes WLFG oversee the management of this proposal. Redirected, reconstituted and organised around the shared interests of all stakeholders, the Middle Ground Coalition referred to above. Provided with impartial leadership and representative of all stakeholders (agencies, river trusts, angling clubs, owners and anglers) it would play the key role in this approach. WLFG traditionally has strong involvement in and experience of the river, its fish and problems. Provided with appropriate support and technical resources, WLFG could create the momentum needed and the focus required to drive results. Its role would be to ensure implementation of all elements of the proposal, continuously monitoring progress and evaluating effectiveness of approach. It would reassess interventions, set priorities and report progress towards the aim of delivering agreed targets.

Note!
Currently the WLFG acts as a communication link on fisheries management, enforcement and related issues, providing a forum seeking views and advice and the exchange of information, It endeavours to raise awareness in the fisheries community regarding the development of fisheries resources and the ecological, biological and economic impact of emerging and new issues affecting fisheries. It seeks the sharing of good practice and facilitates partnership working. In the WSA opinion the WLFG has become too bureaucratic, overly concerned with NRW procedures, particularly restructures and reorganisations or updating members on matters well able to be communicated successfully elsewhere, often already having been so, in other forums, newsletters or blogs. The WLFG would continue to provide this regular feedback for anglers, fishery owners and angling clubs, acting as the communications link between NRW, the project and the fishery community using a dedicated website.

AP1 ACTION

Development of a revised WLFG structure, leadership, technical support, budgets and terms of reference for overseeing and delivery of this proposal. Impartial leadership and representative of all stakeholders (agencies, river trusts, angling clubs, owners and anglers). WLFG would be required to create momentum needed and the focus required to drive results. Its role would ensure implementation of all elements of the proposal, continuously monitoring progress and evaluating effectiveness of approach. It would on an annual basis report and publish formally on progress toward objectives, success of countermeasures adopted and statistical documenting of achievements with respect to conservation levels, adult and juvenile stocks, pollution levels, water quality, etc. This reporting will include a SWOT [Strengths, Weakness', Opportunities & Threats] analysis and should be subjected to peer review.

DELIVERY

The provision of a skilled, focussed and stakeholder driven team capable of delivering project target Management Level [ML} of egg deposition. Visibility in the angling and local tourism communities of recovery progress. Accountability.

3.2 Water Quality

Fish require clean water with adequate volumes and flows to survive and river flow variations are important for migration and reproduction. For more than two centuries, people have altered rivers to harness their power and to use their biological richness and fertile floodplains for various social and economic purposes. The river Wye is regulated primarily for the supply of water for domestic, agricultural and industrial use and for flood control. River regulation can alter water quality, either by affecting water flow or by changing the morphology of the riverbed itself.

Following the introduction of EU Habitats Directive in 1994, the river suffered excessive abstraction. Research by David Solomon for the EA showed that if salmon were held back in the estuary for over 15 days, up to 3% perished each day. Changes to flow regimes can potentially help salmon upriver.

The Usk and Wye Abstraction Group, with NRW and the Environment Agency have explored solutions that provide the best available environment for the rivers and their protected species and habitats, whilst minimising the impact on water company supplies. A number of abstraction licences have been varied under the Habitats Directive review of consents to protect the Wye and Usk SACs (Special Areas of Conservation).The improvements implemented include: increasing releases from reservoirs to support abstractions at low flows; extra reservoir releases during and after spates to reinstate natural flows and encourage fish migration; reductions in abstractions

NRW identifies, investigates and solves environmental risks or problems caused by unsustainable licensed water abstraction through considering what level of environmental impact abstractions are causing or could cause. NRW then work with those abstractors to find effective solutions. The changes made are aimed at restoring water levels in rivers, streams, lakes, wetlands and marshes. They also improve wildlife habitats and protect fish, endangered species and provide opportunities for human recreation.
The right to abstract water from the Wye and its tributaries was created by the Water Act of 1963, amalgamating previous licences into a single permitting regime. This was done with little or no consideration of what level of abstraction the river could sustain. Since that time, there has been a significant increase in use of water for irrigation of crops. It is our belief that the current regime is therefore no longer fit for purpose and has resulted in significant damage to the river environment, its salmon stocks and hence its fishery. Concerns remain with owners and anglers on river levels and flows and there is anecdotal evidence of apparent abuse of abstractions regulations.

AP2 ACTION
To avoid significant ecological damage, the policy regarding how and when water is abstracted needs to be urgently reviewed, revised and then enforced. Complete reform of existing water abstraction licensing is required.
DELIVERY
A water abstraction regime and regulation confirmed by WLFG as functioning and minimising ecological risks

The effect of water temperature changes on juvenile salmonids can be significant. Temperature influences both the period of incubation of eggs, the time of emergence, and the subsequent development rate of alevins. Although sometimes beneficial, premature hatching may be lethal if the timing mismatches the corresponding growth, or migration, of predatory species. A suggested maximum survival of well-formed fry at first food intake is between 6°C and 10°C water

temperatures. In one study at 12°C the population fell dramatically (0.9% survival rate for well-formed fry at first food intake) and fry had almost no yolk sac at first food intake. At 4°C, survival rate was high (76.4% at first food intake). Studies suggest increased water temperatures were likely to adversely affect other factors such as the toxicity of many pollutants. The solubility of oxygen in water falls as temperatures rise. Salmonids are a cold adapted species, requiring high levels of oxygenated water, lower oxygen levels and higher temperatures are likely to adversely affect the young stages, which are more sensitive to higher temperatures. The susceptibility of salmonids to pathogens and parasites could also be influenced by higher than normal temperatures.

AP3 ACTION

Continuous temperature monitoring project in eleven spawning tributaries and including interstitial monitoring. Three years data has been collected. This data will be collected for another three years and will be collated with data being gathered by Cardiff University PhD student, Rowena Diamond, to form the basis of her research and reporting.

DELIVERY

A review of results determining if they form a basis for further action within this management process.

Temperatures in the river, particularly during summer are now being recorded up to 23^{o}C to 24^{o}C. There is a general understanding that sustained temperatures above 19^{o}C are detrimental to the wellbeing of salmonids. **(**Crisp 1993) indicated that the species shows signs of stress at approximately 22°C and that upper lethal limits were between 25°C and 28°C.

AP4 ACTION

Many owners have acted responsibly in closing their fisheries. However, we believe legislation should be considered. WLFG should establish an upper temperature limit and if monitoring suggests anglers/owners are not heeding advice to cease fishing should propose mandatory legislation.

DELIVERY

A salmon fishing temperature based regime fully supported by and signed up to by owners and anglers

3.3 Habitat

Salmon are a territorial species, habitat variables such as water depth and velocity, river-bed substrate and in-stream cover influence juvenile densities. Large cobble and boulder substrates are favoured by juveniles in high-energy rivers such as the upper Wye and its tributaries. Low-energy rivers such as much of middle and lower Wye historically featured Ranunculus (water crowfoot) beds, which offered shelter from both predators and high-water velocities. Ranunculus encourages complex habitats to develop with a mix of water velocities. This is beneficial to juvenile salmonids because they use high velocity habitats for foraging. They maintain position in low velocity adjacent to a section of high velocity that brings their macroinvertebrate prey to them, so they can dart out to capture prey without expending too much energy. This is well documented foraging behaviour.

An additional consideration is the influence of the colonisation potential of a site. After emergence from spawning redds, salmonid fry will disperse downstream until they reach a suitable habitat to feed and grow before overwintering, therefore the proximity of redds to a site will influence the

densities found there. To thrive, salmon need areas of variable habitat to seek shelter and have access to suitable food. If these conditions are not met, then it is unlikely that salmon will attain enough numbers to be within conservation limits.
Historically measures aimed at remedial action to restore river habitat quality and to address other factors operating in the freshwater environment have been implemented largely by WUF. Such improvements as; fencing out grazing animals to allow bankside vegetation to regenerate in a natural way and protect against excessive erosion in high flows; managing the tree cover to produce dappled shade and cutting back multi-stemmed trees to single stems, allowing enough light into the river channel to enable plants and algae to grow, kick-starting the ecosystem; laying or pleaching-in hazel and smaller stems horizontally with the flow to create cover and protection for juvenile salmonoids. Severe erosion is also corrected by grading the banks and protecting their base with alder stems pinned to the bed.

AP5 ACTION

The success or otherwise of restoration projects can only be properly assessed after the entire life cycle of the salmon has been completed – usually requiring about 10 years. A full review should be held by WLFG, with providers, to establish detailed results for all completed habitat projects. Evaluate 'what worked and what didn't' in order to agree a programme of future projects to be included within this management process.

DELIVERY [to be read in conjunction with actions 6 & 7]

A four fold increase in salmon parr densities as reported by NRW Annual Juvenile Salmon Report. Current [2018] level = 3 parr/100m2. Target = 12 parr/100m2

Salmon spawn on sections of silt free gravel, excavating shallow depressions (redds) in which they lay eggs. The presence of large amounts of silt can reduce the hatching success of the deposited eggs. During incubation and the emergence of fry, the inter-gravel physio-chemical environment is critical, and a flow of water through the gravel is especially important. The proportion of fine material in the gravel must therefore be relatively low. Ideally most of the breeding grounds should be taken up by riffles over which the waters flow fairly fast, the substrate varied with gravel and stones of various sizes. This ensures a range of current conditions near the bottom and provides obstructions to vision between each salmon parr and its neighbour, reducing territorial aggression. This substrate condition, distinctly lacking in the Wye, is a feature of the River Tweed, where average salmon parr densities are 5 or 6 times greater than the Wye.

In many places the Wye suffers from excessive silt, often as result of bank erosion or run-off from agricultural land, compaction of the gravel can further reduce hatch rate. Cleaning potential redd areas prior to spawning can significantly increase salmon spawning and egg incubation success. The benefits of cleaning can boost the number of young salmon in a river, provided that there is sufficient fry and parr habitat present near to the spawning sites. Gravel loss, from extraction and natural downstream passage and in the case of the Wye, much of its natural source of gravel being blocked by the damming at the Elan Valley Reservoirs has a significant effect on spawning areas.

AP6 ACTION

Re-gravelling of the Elan river appears to have been a success and efforts should now be concentrated on extending re-gravelling and bouldering [provision of bottom obstructions] to other smaller historical spawning, now barren, sites.

DELIVERY
As per action 5

AP7 ACTION
Sedimentation/siltation of spawning gravels is a major constraint on spawning. Many historical spawning sites have suffered, linked mainly to agriculture. Gravels need de-compacting by mechanical means in order to release areas for potential spawners.
DELIVERY
As per action 5

3.4 Barriers

Structures such as weirs, fords and culverts may form insurmountable barriers for the upstream spawning migration of adult salmon and for downstream juvenile migration. In many cases, this factor is considered a major cause of Atlantic salmon population declines. Smolts are vulnerable to the impacts of barriers on downstream migrations. Where barriers exist, effective upstream and downstream fish passage facilities are critical to restoration success. 15 years ago, around 60% of The Wye was inaccessible to fish, now fish can travel freely along almost all of it. Much work has been carried out on the Wye to remove blockages and barriers and in several sites fish passes have been installed allowing upstream progress of potential spawners and downstream migrating juveniles.

AP8 ACTION
A full review and assessment should be held to establish the impact of remaining barriers on down and upstream migration, identifying a list of actions to address and complete in order to agree future projects to be included in this management process.
DELIVERY
Barrier removal prioritised by WLFG as required to support this programme

3.5 Pollution

Pollution in freshwater is perhaps the single most significant 'in river' factor in the decline of salmon populations. Most comes from domestic, agricultural or industrial wastes and can be lethal to fish. Even at sub-lethal levels, pollutants can raise the susceptibility of fish to other threats, such as thermal pollution. Fertilisers cause over-enrichment of nutrients (eutrophication) with a resultant loss of fish productivity. In the worst cases, salmon stocks may be totally lost.
Across Wales and England our land and our rivers are used as a means of waste and sewerage disposal. In some cases, regulations control the discharge to limit the impact. However, there remain risks of pollution from both permitted discharges, diffuse sources and from accidental discharges.

The River Wye itself has a high level of protection under European law as a Special Area of Conservation (SAC). This includes the river Lugg tributary as far as Hope-under-Dinmore. The Environment Agency (EA) regularly checks phosphate levels in the SAC, and the tributaries that feed into it, to ensure that they stay below agreed ceilings. In recent years both the river Wye and, more particularly, the river Lugg [see figure 5 below] have been over the ceiling with no clear trend of improvement across the catchment since 2015. Many tributaries are seen to be significantly and consistently over the ceiling (see figure 6 below).

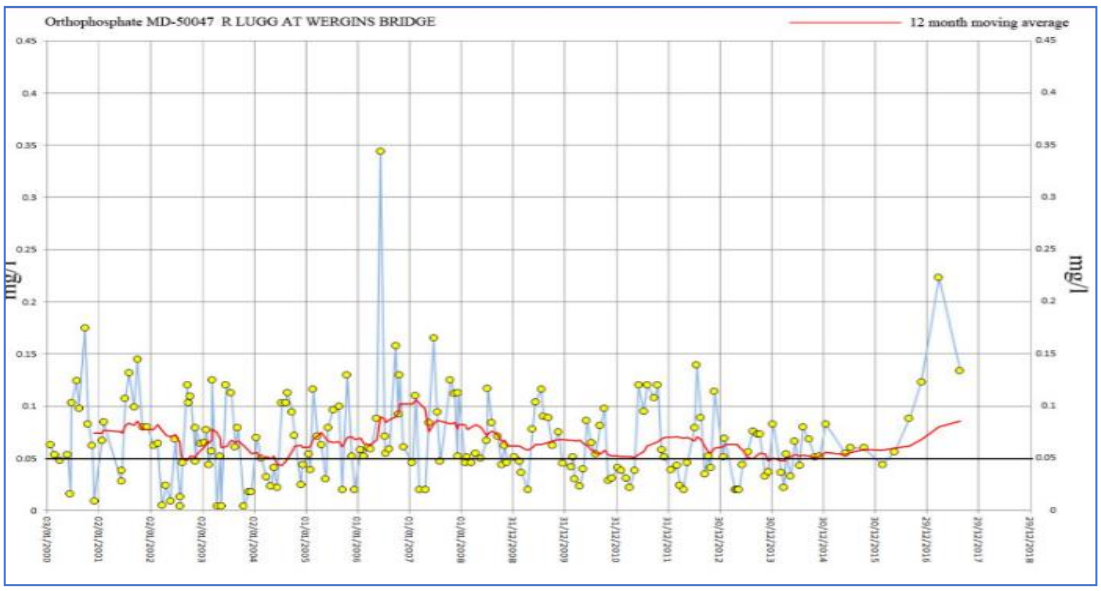


Figure 5: River Lugg at Wergin Bridge

Herefordshire County Council (HCC} and Powys County Council (PCC) , as the regulatory bodies for the Wye and Lugg, have a legal requirement to ensure that high water quality is maintained. They are required to assess whether developments that take place within the SAC will impact on the rivers' integrity and should only permit these developments if there are no adverse effects.

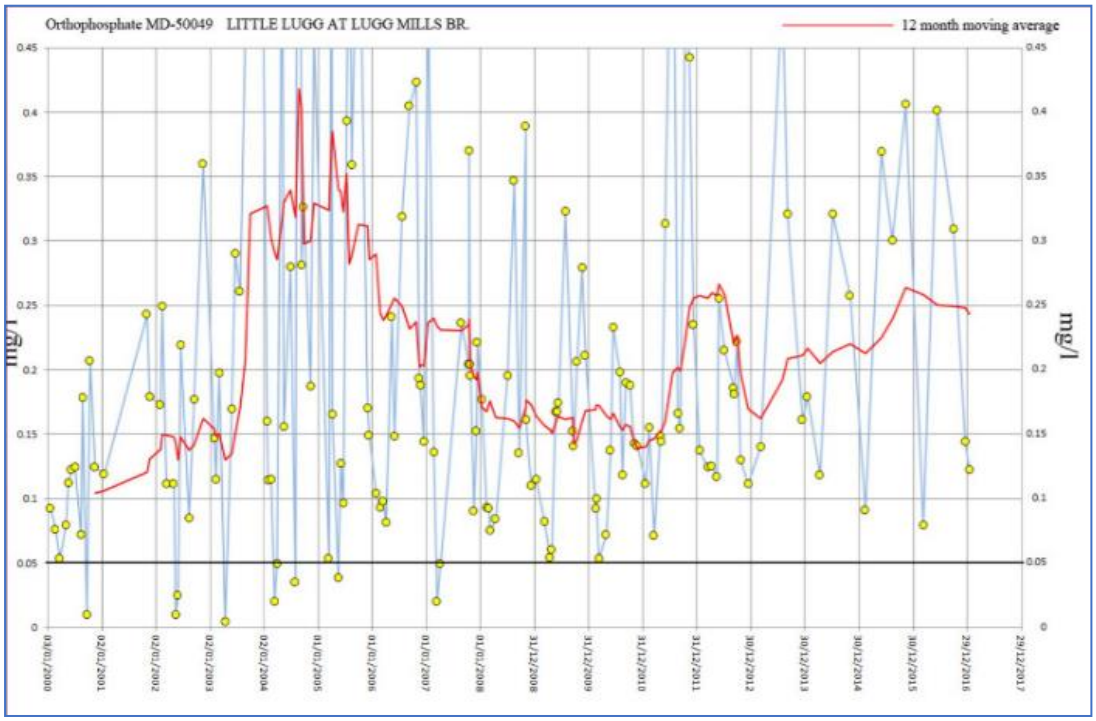


Figure 6: The Little Lugg at Lugg Mill

The Lugg was found to be failing its favourable condition status because of high levels of phosphates, and although the Wye was deemed to be within its required status there was growing concern that wastewater discharges, and especially phosphates, arising from planned future development would ultimately lead to deterioration in water quality. It was important to ensure that this did not take place.

Too much phosphate can lead to blooms of toxic algae, harmful to fish as well as humans and animals, speeding up eutrophication and causing severe reductions in dissolved oxygen levels. Phosphate will stimulate the growth of plankton and aquatic plants which provide food for larger organisms, including zooplankton, fish, humans, and other mammals. Plankton represents the base of the food chain. Initially, this increased productivity will cause an increase in the fish population and overall biological diversity of the system. But as the phosphate loading continues and there is a build-up of phosphate in the water ecosystem, the aging process of the water ecosystem will be accelerated. This can lead to an imbalance in the nutrient and material cycling process (Ricklefs, 1993). Excessive nutrient inputs, usually nitrogen and phosphate, have been shown to be the main cause of eutrophication over the past 30 years. This aging process can result in large fluctuations in water quality and trophic status and in some cases periodic algae blooms.

Two main sources of phosphates are sewage works, (bodily waste is rich in phosphate), and agricultural run-off from land surrounding the river. This too can contain a lot of phosphate from animal waste as well as phosphate bound up in soil particles. The kind of farming carried out, and how it is managed, has a big effect here. EA staff claim a ratio of 70/30 with Sewage Treatment Works (STWs) being the worst offenders.

Generally, discharges from STW are monitored and controlled by the issue of Permitted Discharge Consents, but diffuse pollution depends upon things which are less easily regulated such as the way in which land is managed, whether manure heaps are properly sited, whether stock are fenced from rivers etc. Although both sources need to be tackled, the mechanisms are therefore very different in each case.

Collaborative working between the local authorities HCC and PCC, Natural England (NE), the Environment Agency (EA), Natural Resources Wales (NRW), Wye and Usk Foundation (WUF), Dwr Cymru Welsh Water (DCWW) , Farm Herefordshire, the NFU and the CLA has enabled the development of a Nutrient Management Plan (NMP), implementation of which it is claimed will ensure the River Wye & Lugg reduces the average phosphate load to less than 0.05mg/l.

Both point source and diffuse source pollution are being reduced, but they require different approaches:

- Point source pollution is being addressed by DCWW, which operates the STWs . DCWW is modelling and implementing cost effective measures to reduce the phosphates present in wastewater discharged from the works.
- Diffuse source pollution in Herefordshire is being addressed by Farm Herefordshire, a local initiative comprising twelve organisations that are collaborating to support farmers in improving their soil and water management. Farm visits in the catchment are carried out by the regulatory body which is the EA or advisory visits by a non-regulatory organisation such as WUF and Catchment Sensitive Farming.
- In Powys monitoring of pollution and regulation of discharges and pollution incidents is carried out by NRW. Partnership projects and the agri-environment scheme Glastir also seek to reduce diffuse inputs by appropriate land management measures. Welsh Government provides advice through Farming Connect. The WUF also works to support farmers to improve their soil and water management.

In July 2019 NE notified HCC it had updated its legal advice and would no longer be able to support planning applications that could detrimentally affect the River Lugg catchment, and part of the River Wye, unless it was certain that the level of phosphates in the river could be brought into compliance. The regulator is concerned increases in phosphates in the Lugg catchment, generated as a result of wastewater from new developments, could lead to algal blooms starving the water of oxygen and killing aquatic species. The regulator's updated advice is based on a 2018 ruling in the European Court of Justice, known as the 'Dutch case'.

While nitrogen and phosphorus pollution from waste water and agricultural run-off entering European nature conservation designations is not new, a QC, advised that local authorities whose local plans could affect EU-protected sites should be concerned, particularly those in draft form as they may need to carry out more "appropriate assessments", which could lead to delays.

An appropriate assessment looks at the potential adverse effects of a plan or project, in combination with other plans or projects, on SACs and other EU-protected sites known as Special Protection Areas. This may mean some sites [near SACs] are not deliverable in a council's emerging local plan, and because we're dealing with law and not policy, it's not possible for planners to simply exercise their discretion to place more importance on delivering houses."

The latest Dutch cases places an emphasis on the certainty of proposed mitigation measures. Recent case law has raised the bar on what certainty means. You must have mitigation in place, which has scientific evidence to show that there will be no likely significant effect on the conservation status of the European site.

Since the 1990s, phosphate loads in the Lugg catchment fell from around 0.2 milligrams per litre to a low of 0.08 mg/l in 2015, around the time the council signed off on a nutrient management plan to bring the level of phosphates within the legal ceiling limits to 0.05 milligrams per litre by 2027. Since the plan was put in place, measured phosphate levels have been increasing, upwards of 0.1 mg/l as of 2018.

There are 45 EA sampling points on the Upper Wye and Lugg catchments within Herefordshire and 38 in Powys. However, it has recently emerged that around 2017 the EA, as a cost-saving measure, stopped sampling at 37 out of the 45 points. In effect, the EA has reduced sampling to the bare minimum to be seen to be meeting its legal duties in respect of the SAC. Herefordshire CPRE on their website comment 'this a desperate loss which can only make it more difficult for the NMP Board to target resources and meet its 2027 deadline'.

Reported phosphate levels are based on manual sampling taking place on a once a month basis.

Phosphorus cycles through the environment, changing form as it does so. Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Animals get the organic phosphorus they need by eating either aquatic plants, other animals, or decomposing plant and animal material. As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again.

In a stream system, the phosphorus cycle tends to move phosphorus downstream as the current carries decomposing plant and animal tissue and dissolved phosphorus. It becomes stationary only when it is taken up by plants or is bound to particles that settle to the bottom of pools.

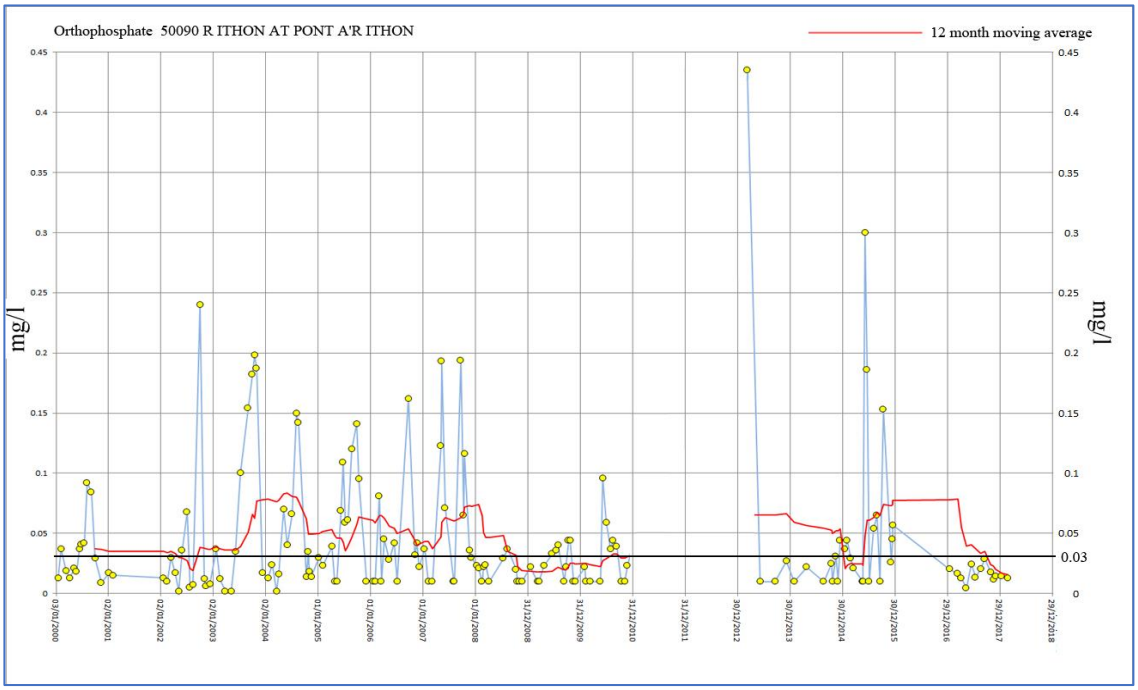


Figure 7: Ithon at Pont a'r Ithon

Anyone using the river in recent years must have experienced the situation all along the river regarding long stretches of 'dirty water' even at low summer levels. Usually the result of algae blooms, anecdotal evidence talks not only of the aesthetic issue but more importantly its effect on rod catches. Often coupled with periods of high-water temperatures the effect is dramatic with salmon appearing to be impossible to catch.

Phosphate monitoring is notoriously difficult, particularly given the in-river cycles as described in paragraph above and the effect of water conditions [spates, run offs from reservoirs droughts, etc]. Results from monitoring of the Ithon, a significant Wye tributary [figure 7 above] shows the range of data that can be recorded. Given the high level of protection afforded the Wye under European law as a Special Area of Conservation (SAC) and phosphates position as one of the most important and serious pollutants reducing recording, as a cost-saving measure, to the bare minimum to meet their legal obligations in respect of the SAC requirement is in WSA opinion a desperate loss, and can only make it more difficult to hold transgressors to account.

Whilst actions referred to above [point source pollution is being addressed by DCWW, diffuse source pollution in Herefordshire is being addressed by Farm Herefordshire and In Powys partnership projects and the agri-environment scheme Glastir seeking to reduce diffuse inputs by appropriate land management measures] are developing the following actions are required.

AP9 ACTION

Establish a statistically valid monitoring regime reflecting the diversity of water conditions on phosphate loadings in Herefordshire and Powys sections of the rivers.

DELIVERY

Validation of Nutrient Management Plan [NMP] reported phosphate loadings

AP10 ACTION

Establish monitoring of key STW sites and point sources. Ensuring published remedial programmes taking effect and actions are being instigated where results deteriorating.

DELIVERY

Report on progress of STWs towards compliance

The number of chicken farm operations has exploded dramatically in Powys, Herefordshire and Shropshire, and along the river Wye and its tributaries and feeder streams specifically (see Appendix 1). A phrase often used in conversations and consultations with NRW and the EA is 'adoption of precautionary principles'. Cumulative pollution aggregation seems to be lacking when planning applications are considered. There is concern about the hundreds of thousands of tonnes of waste produced by poultry units in these counties. Much of this is spread on fields as fertiliser with the risk that nutrients and toxins get into the rivers, causing pollution.

In June 2018 Neil Hemington Chief Planner, Planning Directorate, WAG in a letter to all Heads of Planning said 'Intensive agricultural units particularly pig and poultry farms, can affect both sensitive habitats and the local population. This is largely through the release of pollutants, including: ammonia; nutrients from manure, litter and slurry; effluent discharges; dust; odour; and noise. There is the need to exercise particular care when considering developments which would bring livestock units within close proximity to sensitive land uses such as homes, schools, hospitals, office development or sensitive environmental areas. Importantly, while an individual intensive livestock development may be acceptable, the cumulative impacts resulting from similar developments nearby should also be taken into account. To assist in the consideration of these developments, last year Natural Resources Wales (NRW) issued updated guidance for the assessment of potentially polluting emissions from intensive poultry units. This guidance is for use by LPAs, and their respective Environmental Health Departments on any relevant applications. The same advice is used by NRW in the environmental permitting process for sites holding over 40,000 birds. While environmental permitting and local controls, such as statutory nuisance, may manage the ongoing effects of development, the planning system should consider the relationship between neighboring and potentially conflicting land uses in the first instance'

NRW guidance notes referred to by the Chief Planner , state: 'NRW are responsible for regulating intensive pig and poultry farms under the Environmental Permitting Regulations (EPR)'. These were formerly called the Pollution Prevention and Control (PPC) Regulations. Pig and poultry farms can affect the environment through the release of pollutants. These include ammonia, nutrients from manure, litter and slurry, effluent discharges, dust, odour and noise.

A link [to the NRW website] at bottom of the letter referred to NRW responsibilities under the Environmental Permitting Regulations (EPR). In particular that regulation required farms that exceed their capacity thresholds hold an environmental permit to operate.

AP11 ACTION

Seek clarification, and continue to monitor, that Planning Directorate instruction and NRW environmental permitting controls are; being adhered to by all planning authorities affecting Wye catchment, are proving effective in controlling situation and farm capacity thresholds are being effectively regulated by NRW.

DELIVERY

Planning Authorities complying with directives and permitting controls. Provision of evidence for regulatory action

Poultry litter contains more phosphorus than any other farm manure as well as arsenic and other residues. Other factors that pose a risk to the ecology of the river and specifically salmon stocks
Higher temperatures often coincide with summer low flow conditions, including low dissolved oxygen. Seasonal droughts exacerbate these sub-optimal conditions. Low flows may prevent movement of salmon to areas of refuge with cooler, oxygenated water, such as small tributaries or groundwater seeps. The protection of riparian zones and in-stream refugia increases the resiliency of the ecosystem to stressful conditions and is therefore important for the health of fish populations. Although adult salmon can accept concentrations of dissolved oxygen down to 5 to 6.5 mg/l, it is generally recognized that concentrations below a single day mean of 8 mg/l O^2 may be harmful to spawning fish (Binkley & Brown, 1995).

Hormone disrupters whilst largely banned in the UK are still widely used to control weeds in maize crops. This herbicide gives cause for concern due to its endocrine disrupting properties, such reduced reproductive success in common amphibians. An example of the effects occurs in salmon. At low concentrations, water regulation capabilities are disrupted which means the fish may be adversely affected during migrations due to decreasing ability to move between fresh and saltwater. Researchers have now linked environmentally realistic levels of these herbicides with the negative affect on osmo-regulatory processes limiting the ability of salmon to migrate. Research also suggests significant mortality of salmon smolts exposed to environmentally relevant levels when they were exposed to seawater, hence highlighting the disruption in salmon migration (Waring and Moore, 1996).
The same research showed the herbicide also has a negative impact on olfactory systems in salmon. Inhibition of olfactory detection of female pheromones occurs in male salmon exposed to environmentally relevant levels. This impairs breeding, because the male salmon will not be ready for breeding at the same time as the females (Waring and Moore, 1998).
Pesticide spray solutions are suspected of having been a factor in massive losses of juvenile salmon. Researchers have noted a close correlation between watersheds where pesticide was sprayed and observed decrease in numbers of salmon returning to those rivers in subsequent years. There is some evidence the impact has manifested in an inability of juvenile salmon to survive the physiological transformation required to move from fresh to saltwater. (Fairchild et al., 1999).
Some pesticides are thought to imitate the female hormone system and interfere with reproduction capability of a wide variety of animals. Usually they cause fish to lay eggs that do not hatch or contain defective embryos. Although pesticide containing, in particular, nonylphenols has not been used since 1985, a key ingredient is still used in a wide variety of cleaning chemicals and industrial processes, and still enters rivers.

Removal of phosphate is usually carried out by dosing metal salts commonly, aluminium and iron. Because of their sensitivity to changes in pH, and in particular to aluminum, salmon alevins and smolt are among the first organisms affected, altering the ion exchange balance through the gills. Ultimately, when pH is reduced below 5.4, conditions may prove lethal to salmon. The stage transforming the smolt from a freshwater to a saltwater fish seems to represent the most sensitive period. Salmon smolt exposed to quite low concentrations of labile inorganic aluminum (< 25 mg/l) have suffered physiological disturbances and even death in subsequent exposure to salt. Mortality of smolt in the marine environment after running from moderately acidified water is therefore expected

AP12 ACTION

Given the risk herbicides, pesticides and other chemical and chemical reactions potentially pose to the salmon life cycle, establishment of a statistically valid monitoring regime reflecting the diversity of water conditions in Herefordshire and Powys sections of the rivers. Actions may result from collected data.

DELIVERY

Water sampling report establishing risks to salmon stocks

AP13 ACTION

Examine opportunity to commission research into chicken feed usage with lowest nitrate/phosphate discharge, plants that take up most nitrate and phosphate that can be harvested and removed from sites. Consideration to the introduction into small watercourses of plant life that takes up phosphate and nitrate, enforcement.

DELIVERY

Opportunities to encourage phosphate reductions

3.6 Predators

Cormorants and goosanders eat mainly fish. They are opportunistic and generalist feeders, preying on many species of fish, concentrating on those that are easiest to catch. Shoaling and migrating smolts would be considered easy prey. Adults are likely to consume circa 35 smolts per day each during the migration period. Scientific articles recently suggested avian predation, Fish Eating Birds (FEBs) of smolt runs to be in excess of 40%. That would suggest a loss to the Wye of some 80,000 smolts, which at 1% to 2% sea survival rate, would suggest a loss of circa 800 to 1,600 returning adult salmon. In dry years with low water conditions restricting downstream migration, losses could be total.

Organised Fish-Eating Bird (FEB) counts during 2017 and 2018 on the Wye showed an average of 233 cormorants and 285 goosanders present during spawning and juvenile salmon growing season. WSA believes in order to protect fisheries better, the current England and Wales licensed shooting limit of 3,000 should now be set around at least 6,000 birds. Recent winters have seen an increase in the number of cormorants migrating here from mainland Europe following colder weather. Over-wintering cormorant numbers by observation from fishery managers suggest numbers are increasing by circa 5% pa.

Action would provide co-ordination and control to maximise efforts to control the predators through a single licence for all fisheries in the catchment, allowing lethal control of cormorants within a defined area. These fisheries would work together co-operatively with NRW to co-ordinate efforts to control cormorants and goosanders by both non-lethal and lethal means. The Primary Contact, NRW would be responsible for the oversight and management of the licence. It would submit a Management Plan for the area to be covered and include details of the fisheries participating within the catchment.

Participating fisheries themselves would divide and allocate the number of predators allowed to be killed at each fishery according to local need, subject to an overall maximum for the area set under the licence. The Primary Contact, the NRW would be responsible for formally informing each fishery of the number of birds it can shoot, following local agreement.

Each fishery would remain responsible for its own actions and compliance with conditions of the licence. A named Site Representative would be responsible for use of the licence at each site named in the Management Plan.

It is anticipated that the proposed licences would allow greater local flexibility to control and reduce damage resulting from cormorant and goosander predation. Co-ordinated action by several parties should result in more effective scaring and displacement of birds from key areas.

AP14 ACTION
Predator control must form part of any recovery plan for salmon on the river Wye, NRW should apply for and manage an Area-Based (Wye Catchment) Cormorant and Goosander Management Licence.
DELIVERY
Control and organisation of the sensitive issue

Goosanders are known to take a range of species including sticklebacks and roach but it is their fondness for salmon and trout which has brought them into conflict with the angling community, some of whom blame goosanders and other piscivorous fish like cormorants, for the steep declines being seen in salmonid populations in rivers across Britain.

Recently, Scottish Natural Heritage has granted licences for killing of a "significant number" of goosanders and cormorants on the River Tweed, where it is claimed they may be a factor in recent salmonid declines. Goosander numbers are on the rise. The first recorded breeding pair in Britain was in Perthshire in 1871 but they have long since spread out from Scotland deep into England and Wales. The RSPB estimates there are now 3,100 to 3,800 breeding pairs and over 12,000 wintering birds. One way of trying to answer this question is to look at what the birds due to be shot under licence have been eating. The Centre of Ecology and Hydrology is planning to do exactly this kind of dietary analysis and is expected to report its findings later in 2019.

AP15 ACTION
Create 'no fly zones', during that important migration period of March to mid-May in key areas impeding and slowing smolt migration and for a significant number of cormorants and goosanders to be killed.
DELIVERY
See below

AP16 ACTION
Support Angling Trust in their position that FEBs should be added to the general shooting licence (along with pigeons, crows, magpies etc.).
DELIVERY
See below

AP17 ACTION
Support of all three actions above should be subject to an annual review and count of FEBs to ensure the conservation status of the birds is not threatened.
DELIVERY
[Actions 16/17/18]
Reduction in high predation of juvenile salmon during growing periods and smolt runs to sea

Seals are unfussy predators which will hunt and eat any type of fish available, including migratory fish such as salmon. When found in rivers they will also feed on any freshwater fish present. The

specific reason why seals choose to swim inland is uncertain, but suggestions have been made that they are simply following a food source, e.g. a salmon or sea trout 'run' at a particular time of year. Regularly between 2 or 3 seals are seen fishing the weir at Llandogo, and often as high as Bigsweir. In general, seals consume 4 percent to 6 percent of their body weight daily. An average male grey seal weighs approximately 880 pounds and requires 35 to 52 pounds of food daily. Its diet consists of fish, crustaceans, squid and octopuses. So possibly 4 or 5 MSW salmon per day, potentially 1,250 fish in the season (assuming they abide by the byelaws)! In the last two years the stock of salmon in the river Wye has been circa 3,000, so a potentially significant impact in a period of low numbers!

Questions are often raised as to what can be legally done to resolve the issue. More often than not the seal will naturally return to sea within a few days. Alternative measures often discussed include the live trapping or netting of the specific seal, lethal shooting or the use of acoustic deterrents.

Lethal control using a qualified marksman under licence would undoubtedly result in a strong expression of public disapproval. Once again there would be logistical issues to consider should that option be considered, not least the safety requirements of using a rifle in this environment over water. Before any such licence could be considered all reasonable and practical non-lethal deterrents would have to have been considered. One such option would be the use of acoustic deterrents.

In England, the Canal and Rivers Trust has trialled the use of acoustic deterrents at the Tees Barrage where seals not only predate on salmon waiting to pass through the barrage but also use the navigation lock to access upstream to highly valued coarse angling waters. Attempts are continuing to be made to find a solution to this.

The principal piece of UK legislation is the Conservation of Seals Act 1970 which prohibits the killing or taking of seals by certain methods and during close seasons. Both seal species are Annex II species protected under the European Habitats Directive in sites known as Special Areas of Conservation. Seals are protected within these sites from any activity that could impact the favourable conservation status of that population, which could include restrictions on control.
Acoustic deterrent devices (ADDs) work by emitting a noise from an underwater speaker that either causes pain or is distracting enough to create an aversion and causes the animal to flee an area. They operate at various duty cycles (amount of time a device is active during an on-off-cycle), pulse durations, and frequencies. Most require a car battery (approximately 12v), a transducer, amplifier and a speaker.

A Lofitech Seal Scarer device fitted in the River Conon and the River North Esk, Scotland, reduced seal movements upstream, past the device, by approximately 50% when the device was switched on (periods of several days, up to one month continuously). Another study in the same river placed an Airmar dB plus II ADD at a bridge foraging site. This prevented seals feeding within a 50m radius of the ADD (compared to a mean of eight individuals feeding in the absence of the ADD (MMO 2018) It may be the case that ADDs are effective in protecting relatively small areas such as narrow rivers (Harris et al, 2014), as acoustic signals vary depending on topography and are more constrained in a river environment (Gordon and Northridge, 2002; Northridge et al., 2010). Therefore, ADDs deployed in open sea locations may be less effective compared with semi-enclosed locations, and therefore potentially suitable for use in the river Wye.

AP18 ACTION
Trialling and placement of an acoustic deterrent device [ADD] on the weir at Llandogo, a site regularly visited by seals.
DELIVERY
Reduction in loss of adult returning salmon in tidal lower river

3.7 Fishing

New byelaws will become law on all rivers wholly within Wales on 1st January 2020, further controlling exploitation and survival of migratory fishes, and include; full catch and release fishing on all net and rod fisheries for salmon; controls on use of bait, barbless hooks and treble hooks so that released fish have the best chance of survival; making consistent the start and end of the net fishing seasons by shortening the netting season by starting net fishing no earlier than 1st May and ending the netting season on the 31st July.

However, there remain some glaring inconsistencies from both a logic & fairness point of view that should be considered for remedy.

AP19 ACTION
Coarse anglers use worms and barbed hooks to fish for barbel/chub in the same swims that salmon anglers use. Byelaws should be amended to reduce the risk already exposed by existing and new laws to salmon numbers. Coarse byelaws to be brought into line with salmon byelaws.
Pike anglers use barbed trebles on spinners, salmon anglers cannot. Similar to previous point byelaws to be brought into line.
DELIVERY
Uniformity, simplification of bailiffing and fairness in byelaws

AP20 ACTION
An existing byelaw bans the use of maggots from March 3rd to October 17th, because they are likely to catch and threaten survival of salmon parr smolts. Concessions are commonly given to coarse angling clubs. Given current threat to salmon numbers, these concessions should be withdrawn until juvenile numbers achieve their Conservation Level (CL) on a consistent basis.
DELIVERY
Elimination of a potential source of parr and smolt mortality.

3.8 Juvenile Enhancement

The role of juvenile enhancement is fundamental we believe to the future of salmon stocks in the river Wye. Many programmed initiatives and interventions are medium and long term. In order to support the wild population until such time as the river, supported by the delivery of interventions in the six areas of concern, significantly exceeds its Conservation (egg deposition) Levels, the WSA proposes stocking as an overarching principle. With no visibility of stocks achieving conservation levels in the foreseeable future, time is running out for the remaining Wye populations of salmon.
Juvenile Enhancement is of little value if the fundamental problems are not addressed. The results of the last 20 plus years of river restoration suggest more needs to be done. Enhancement of numbers should thus only continue whilst it is used as a support tool, and it may be discontinued

when populations are self-reproducing and can withstand the fishing pressures.

However, whilst providing essential, urgent and a robust, much needed boost to stocks whilst some of the fundamental problems take inevitable slow routes to maturity. Juvenile enhancement might also provide a long term term strategic contingency in the event those factors beyond our control, such as sea survival and climate change, defeat our efforts in protecting salmon stocks, and as a result the river Wye SAC status.

There has been controversy recently about the impact of cultured fish on native stocks in terms of the possible genetic implications. There is a fear that cultured fish will integrate with wild fish and dilute gene pools or possibly introduce undesirable characteristics (Ryman 1997, Seagrove et al 1997). There appears to be a general assumption that salmon numbers present in the rivers today are some how "pure" or of a desirable genetic make-up. In fact most of the salmon numbers in European rivers are a result of 150 years of selective exploitation in high seas and homewater fisheries, the Industrial Revolution, settlement influences and intensive agriculture and as such can hardly be considered "natural". The question then becomes "what exactly are we trying to preserve and at what cost to the rivers and the social and economic fabric of society?"

It is becoming increasingly clear that we must adopt a pragmatic aproach to maintaining and improving our river ecosystems, whilst at the same time balancing the needs of industry, agriculture and recreational users. If this means that the "natural" populations of salmon in our rivers is made up of a balance of artificially reared and wild fish to maintain a sustainable level of exploitation, then so be it. Habitat improvements and bye-law changes are important protection measures but can only do so much, it is not realistic to expect a return to pre-settlement days with no pressures on fish numbers. All too often the “human component” is not recognised in balancing our ecosystems, this can only restrict the flexibility of our approaches to solving problems.

The precautionary principle is commendable except that there is a very fine line between extreme protection and inadvertant extirpation, if current trends continue, it may lead to the Wye having only a handful of “pure strain” salmon which eventually become an endangered species. It is time to recognise that fish culture is an essential tool, and not a last resort, for responsible fisheries management and conservation. The WSA is urging the NRW to review its policies and allow a holistic approach to management before salmon become extinct as a self-regenerating species.

Like many rivers feeding the North Atlantic, the number of salmon returning to the Wye showed a marked decline in the early 1990s. Because this collapse was observed across the salmon’s distribution, the consensus was the decline is caused by problems in the marine environment; such as warmer sea temperatures. However, this highlighted the importance of being able to separately analyse the changes affecting survival that occur in freshwater and those that occur at sea. Only by monitoring both smolt output and returning adults are we able to separately analyse the two components of the salmon life cycle.

Stocking is widely carried out by many government and private entities for enhancement, mitigation, restoration or rehabilitation purposes, and advise that while these programmes are usually successful, it is now known that stocking can also have negative impacts on wild salmon stocks when poor hatchery practices negatively impact the characteristics of the wild stock to be conserved. Care must be taken in the design and control of stocking processes to be used in our design.
The proposed juvenile enhancement programme detailed schematically in fig 8 below uses exclusively Wye brood-stock. The programme will be supported by independent monitoring,

provided by the Game and Wildlife Conservancy Trust (GWCT) and Exeter University (See Appendix 2) in order to provide a full scientific evaluation of the contribution of a salmon hatchery to the rod catch.

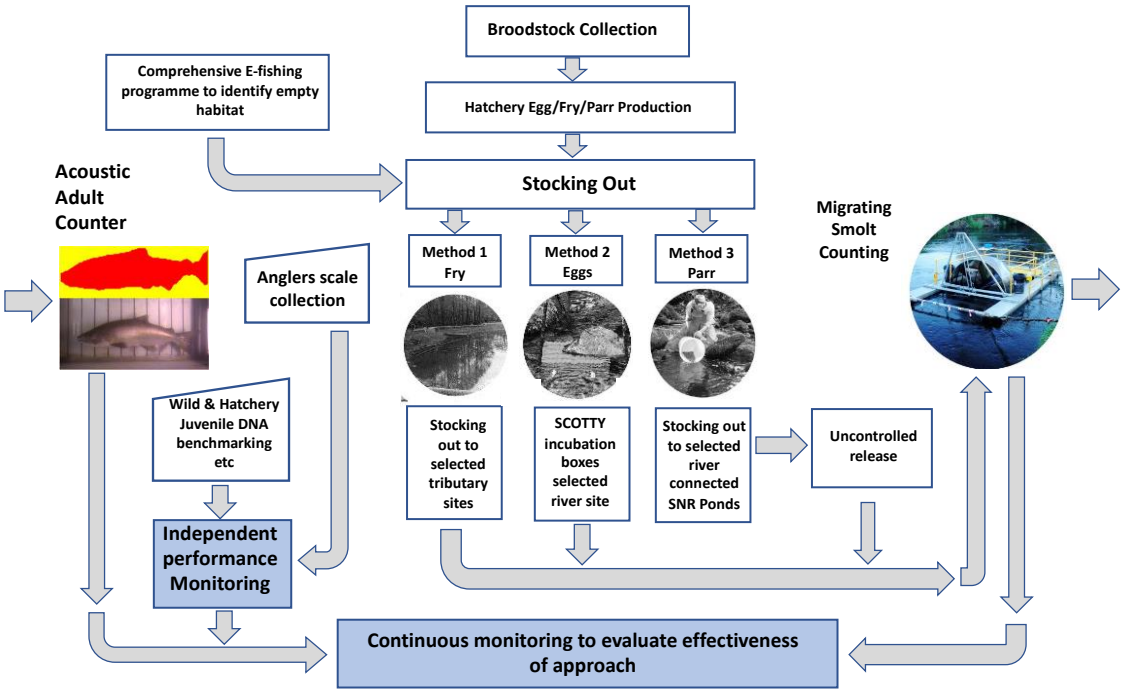


Figure 8: Juvenile Enhancement and Monitoring Process

It is not the intention in this proposal to debate whether or not juvenile enhancement is a useful fisheries management tool and whether it should be used instead of other management techniques such as habitat improvements. These arguments have been put exhaustively over the past few years often being counterproductive and seem only to reinforce deep-seated beliefs. Instead we will focus on how juvenile enhancement can be used as a support for the stock recovery project. Hatchery reared fish can contribute significantly to the rehabilitation and restoration of rivers if planned and executed in the correct manner. Studies of returns of Micro-tagged salmon and sea trout in the Welsh Region of the Environment Agency have shown that stocked hatchery fish can provide up to 35% of the spawning runs of some recovering rivers (Taylor 1998). The recovery of the Morell River in the Canadian Province of Prince Edward Island is undisputedly attributed to the release of hatchery reared progeny using various methods. Such was the success of this stocking scheme (runs increasing from between 4-45 to 360-1236 in the space of eight years) that initiatives were investigated as to how to harvest the surplus grilse run (Beilak et al 1990). The Morell river still has not reached its spawning target for the MSW wild and hatchery reared fish but has a harvestable surplus of grilse (fin clipped) resulting from stocking, this relieves the pressure on natural stocks (Davidson et al 1992).

We offer a demonstrably successful case study (Koed et al 2019) that we consider a very real template for the river Wye. The paper reporting this compiles the last 20 years of salmon management in Denmark, it contains the latest knowledge and has been peer reviewed by at least two independent anonymous reviewers with a relevant scientific background before being accepted for publication in the scientific journal Fisheries Management and Ecology.

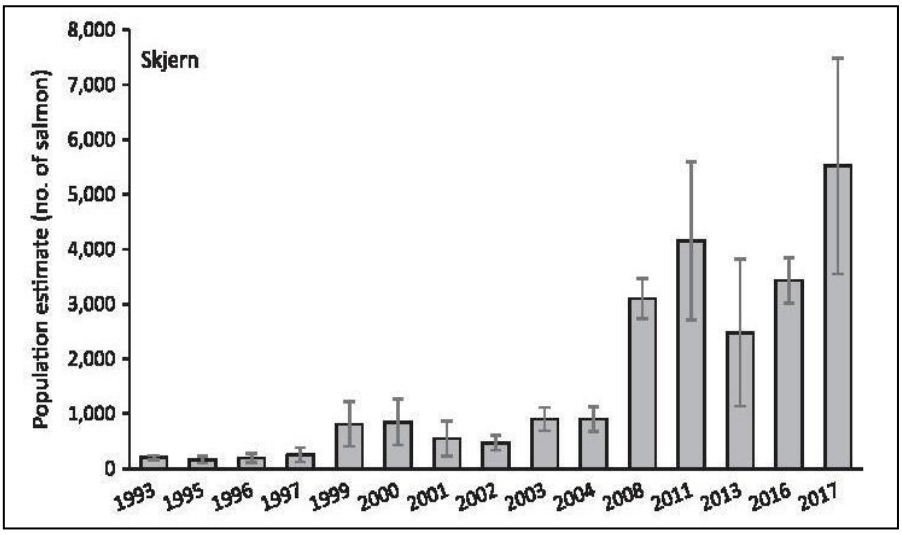


Figure 9: Population estimates of Atlantic salmon from river Skjern

This successful case study demonstrates an approach taken by the Danish Atlantic Salmon Trust which includes changes to legislation, stocking practices, habitat restoration, population genetics and barrier removals that successfully rehabilitated salmon populations in four major Danish rivers. However the sea journeys, feeding grounds and threats to migrating stocks from the Wye and Denmark differ and their outcomes in terms of survival might vary significantly. If it eventually proven that the greatest influence on stocks is at sea, or influenced negatively by climate change, we will need to face up to a situation where stock levels can only be maintained by continued juvenile enhancement. Developing and proving the processes to mitigate genetic and phenotyping risks is therefore an imperative.

Designed sensitively, in co-operation with NRW fisheries staff, to address the issues of genetic diversity, phenotyping and progeny fitness, the WSA proposed juvenile enhancement programme will be complimented by independent monitoring aimed at providing a scientific evaluation of the contribution of a juvenile enhancement programme to the rod catch. WSA has a draft proposal from the Game and Wildlife Conservancy Trust (GWCT) jointly with Exeter University for such a monitoring programme (see Appendix 2).

We propose several different juvenile production methods for consideration in order to develop and monitor for the most effective and efficient method. The three methods chosen are not mutually exclusive and we would wish to discuss in more detail the NRW/EA Fisheries & Aquaculture Specialists views.

The brood stock target is a minimum of 25 males and 25 females to ensure a large enough gene pool (Rasmussen & Geertz-Hansen, 1998).

Method 1: Fry and Parr Release

Fry release would mirror original mitigation stocking, placing fry into selected streams above impassable barriers. However, we propose an intensive electrofishing programme to identify empty habitats in a range of streams not necessarily influenced by impassable barrier. Evidence of recent electrofishing results suggests many potential sites. There is evidence available from past stocking data collection that fry and parr survival from hatchery juveniles can be better than wild fish.

Method 2: Incubation boxes

Incubation boxes would take eggs from broodstock stripped at the hatchery and place them in streams and tributaries deemed suitable in terms of habitat and water quality. This process minimises the time 'in captivity' and has an added benefit of minimising 'phenotyping' identified by Kyle Young in his paper (Young KA 2017) as a major contributor to lack of adult 'fitness'.

Incubator units can be of great help, they are scientifically designed and tested to provide an efficient aid for in stream incubating of fish eggs. Fungus infection is virtually eliminated, and eggs are protected from predators and silt suffocation. Testing and usage indicate that survival rates from egg to fry is often better than 65-95% as compared to natural spawning survival rates of between 5-20%. In nature, high egg loss rates can be caused by poor fertilisation when deposited eggs not being successfully buried, being washed out by spates, fungus from dead eggs spreading to healthy eggs, attrition by predators, and silt suffocation. Incubator boxes address these issues. Egg quality can be checked during the loading process and all eggs are fertilised before loading.

A pair of loaded plates are bolted together to create a "unit" designed to hold 200 single eggs or more, depending on species and size of egg. Plates can be grouped in up to 5-unit sets, so a max of 2,000 eggs per unit. Escape holes allow the hatched fry to swim free once they have developed in their protected environment. The assembled egg units are anchored in streams by securing them to re-bar stakes or some other permanent holders.

As per method 1, placing fry into selected streams identified with empty habitat. They may also be considered for stocking of middle and lower reaches of the main river stem, again where good clean habitat is empty and available.

WSA proposes consideration should be given to this being used to stock former spawning streams above the Elan reservoirs. This may be a novel and challenging way of minimising interference with 'wild' juveniles and, if proven by monitoring to be effective, increase spawning grounds. Given encouragement the WSA would carry out a feasibility study.

Method 3: Semi Natural Rearing [SNR]

The first, that of SNR, a revised method, with lessons learned from the successful project run by the WSA in 2012 - 2014 would to be place a series of ponds strategically along the length of the river taking parr and potentially fry from the Cynrig Hatchery.

SNR differs from traditional fry/parr stocking. It combines the advantages of hatchery technology in achieving high survival rates to early juveniles, with the 'real life' experiences of a wild environment protected from predation. There is substantial evidence that post release survival can be improved by increasing 'real life' experiences (Taylor 1998).

The ponds would be selected close to or in-line with suitable streams for a pilot SNR scheme. Site and pond suitability would be subject to survey and approval by the NRW Fishery and Cynrig Hatchery staff. Viable water conditions, in particular flow rates and water temperature ranges would be key along with secluded but accessible locations. The fish would enjoy foraging on natural aquatic insects and invertebrates with supplementary feeding taking place as required subject to advice from hatchery staff.

A works programme would be prepared and the ponds converted by a specialist contractor, following the advice of hatchery staff, during the Autumn. Each pond site (numbers to be agreed) would be managed throughout the Winter months by trained WSA volunteers under the guidance

of NRW Hatchery staff.

Protection from predators would ensure mortalities are kept to a minimum with survival estimated at 97%. S1 smolts would be released, taking advantage of high-water conditions in the tributaries and main stem at the end of April.

In the previous successful WSA SNR project juveniles grew well in the ponds, gaining average weights approximately 25% heavier than the average S1 smolt grown at Cynrig hatchery. Smolts were in very good condition with healthy fins and body condition, with a survival rate to release of circa 95% compared with wild survival to smolting estimated at circa 1% to 2%.

AP21 ACTION
The precautionary principle is commendable except that there is a very fine line between extreme protection and inadvertant extirpation. The stark reality is if current trends continue, it may lead to the Wye salmon becoming an endangered species. WSA urges NRW to reconsider its policy, at this point in time, and provide for a holistic approach to salmon management.
DELIVERY
See below

AP22 ACTION
NRW Fishery Team to meet with WSA to agree best and most appropriate methodology and controls the juvenile enhancement programme described herein.
DELIVERY
See below

AP23 ACTION
Given AP21 & 22 WSA to prepare a full enhancement project proposal.
DELIVERY
Significant increase in recorded smolt migration trends from enhancement programme as measured by smolt trapping.
Adult returns >0.4% pa of enhancement fish [0.4% of circa 150,000 stock = 600]

3.9 Juvenile Enhancement performance monitoring

The juvenile enhancement programme [see fig 8, p26] would be supported by the use of high-resolution techniques in order to establish genetic identity of all broodfish and the parallel construction of a genetic baseline from wild parr. Genetic signatures obtained from scale samples returned by anglers from rod-caught fish could then be matched to either the hatchery-reared fish or resident wild fish by analysing DNA. Thus establishing in what proportions 'in river' improvements and or juvenile enhancement contribute to measured recovery in stocks.
As part of the proposal, Exeter University would undertake the genetic analysis of juveniles, the adult broodfish and all the scale samples from anglers. A ten-year monitoring sequence would be proposed. Data collected would be used to adopt a 'Plan, Do, Check, adjust' (PDCA) approach and a final report would be prepared jointly by the GWCT and EU establishing the performance of the programme.

Juvenile enhancement would continue until such time as the control body, the WLFG, confirm the management target (MT) for egg deposition has been met and maintained. Re introduction of an appropriate Juvenile enhancement programme could and should be enabled if the MT for egg deposition was seen to fall below expected MTs.

Famously W, Edwards Deming, the statistician said, 'you can't manage what you can't measure'. Well, today on the Wye we seem to measure very little by the way of salmon populations. We therefore propose to; count returning adults in to understand the cycles and levels of adult salmon returning to the river and migrating smolts in order to understand and confirm productivity. We need to understand how much of our problem lies within our control and if countermeasures are working. Inclusive to this stocking programme the WSA propose the installation of a multi beam acoustic fish counter on the lower river, potentially at Bigsweir Bridge and the establishment of annual smolt counting at various points in the lower river.

Members of the WSA Steering Team are researching current best practice technical options available for a counter. Capabilities of counters have significantly improved in recent years and of the 3 basic types of counter currently available i.e. resistive, optical and hydro-acoustic it would appear the last (hydro-acoustic) to be the most viable. The many advances in sonar technology, data acquisition, data analysis, reporting and general computing technology negate the historical negatives.

Several meetings and site visits have taken place to discuss technology, applications and users' experiences, particularly on the Deveron, we are currently discussing the subject with Peter Clayburn of the NRW. We have studied possible site locations and the potential for using existing infrastructure, helpfully installed at Bigsweir Bridge. Before completion we need to consider other new or existing infrastructures.

To complete our knowledge of juvenile production we need to count smolts leaving for their seaward migration to their feeding grounds off the coasts of Greenland each spring. Comparing the numbers of smolts migrating and returning as adults will provide information on the survival rates at sea. Some of this detailed information may also provide an insight into why some survive and why some do not.

Smolt counting is carried out by the operation of a rotary screw trap (RST). A well proven technology, the trap is positioned in the river in spring from late March to mid-May, where it will operate and be manned 24/7. Rotary Smolt Traps must be manned by at least two people for safety reasons, a considerable undertaking, and we will need to provide temporary, but full-time staff (maybe contracted from NRW/EA/WUF) for this work plus trained students and WSA volunteers each year.

As well as providing population data, the adult counter provides information on migration timing and the environmental factors that influence this. For individuals captured by the counter, it also provides estimates of adult fish length, enabling us to look at changes in marine growth over time. The relationship between the freshwater production of smolts and returning adults enables us to quantify the marine survival of separate smolt cohorts.

At this stage costing of and funding for this stocking and monitoring is not complete, the WSA requires a provisional indication of acceptance by the NRW at which time a full costing, funding and resourcing proposal will be completed.

AP24 ACTION

In conjunction with NRW Fishery Team, WSA to review and revise monitoring programme post agreement on detail of juvenile enhancement programme

DELIVERY

Reporting of results from juvenile enhancement programme

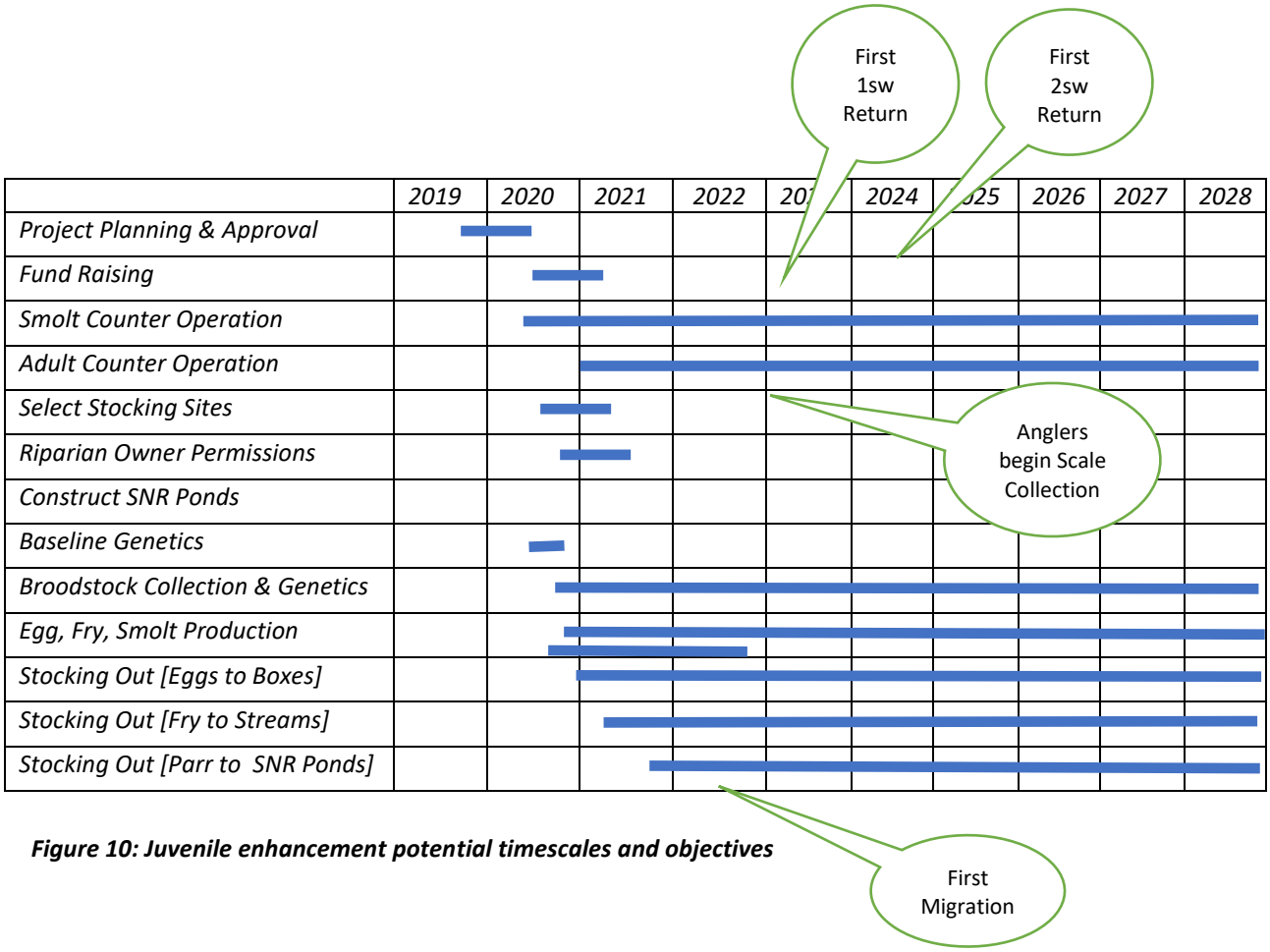


Figure 10: Juvenile enhancement potential timescales and objectives

4. Wye Salmon Association Conclusions

WSA believes the multi-faceted management approach described in this report including changes in legislation, stocking practices, habitat restoration, population genetics and barrier removals, has potential to successfully rehabilitate salmon populations in the river Wye.

Nature is dynamic and recovery strategies must reflect this, which makes management a slow process of continuous monitoring and revision. It is difficult to predict how any management scheme would hold up under current climate predictions, but with continuous population assessments, and an adaptive management approach, management strategies can be adapted quickly to ensure continued sustainable populations of salmon, alleviating potential declines arising from uncontrollable factors such as climate change.

The importance of assessing population production both before, to set benchmarks, and after actions have been implemented is emphasised. It is the best (and sometimes the only) way to investigate the effectiveness of actions. The only way to know how well a strategy is working is by making regular assessments. However, the overriding benchmark is the 'clarity of result' not

achievement 'per se' of task. The result is the delivery of the Management Target for egg deposition.

Efforts focused on establishing the necessary legislation and implementing the appropriate rehabilitation, juvenile enhancement and management review structure is likely to lead to achieving conservation levels in the salmon population. This is not an easy task, however, a reactive management framework can help restore this culturally, economically and ecologically important species. The proposal presented here cannot guarantee success, at a time when the salmon populations of the Wye are on the brink of extinction, all possible measures should be simultaneously employed to avoid wasting valuable time.

WLFG will be required to carry out a full assessment of the impacts of current initiatives on the salmon population and identify shortfalls. They will carry out gap analysis to identify further actions required and seek solutions to mitigate these issues.

A word of caution…….during the period since 1996 sea survival [%age of juveniles [smolts] returning as adults] has fallen from 25% to circa 2%. Current Salmon Action Plans based on river and river corridor initiatives, many in operation in some form or another since 1996, have as yet proven unsuccessful in delivering significant and sustained levels of salmon stocks on the river Wye, as they have on many other rivers in the UK. These river and river corridor initiatives depend on assumptions that the problems lie therein. These assumptions may well be correct, however, we will not answer that question until such time as all such actions are completed. Given the pressures population growth, agricultural pressures and climate change are having in increasing these threats that may well be many years in the future!

The overarching principle in this WSA proposal is that juvenile enhancement be used to maintain and improve stocks whilst proposed in river actions have time to come to fruition.
We offered the demonstrably successful Danish case study (Koed et al 2019) as proof such methodology can succeed. However the sea journeys, feeding grounds and threats to migrating stocks from the Wye and Denmark differ and their outcomes in terms of survival might vary significantly.

If eventually proven that the greatest influence on stocks is the extent to which historical activities such as the Greenland Net Fishery have impacted on population dynamics and reproductive potential, we might need to face up to a situation where stock will fail to recover and stock levels in rivers can only be maintained by continuing large scale juvenile enhancement. Developing and proving effective and efficient processes to population structure, phenotypic plasticity, genetic drift and adaptability and other risks is therefore an imperative.

Finally, a stark warning of timescales. Every year that goes by means solutions to salmon stock recovery are still 5 years away. NRW Annual Salmonid Report of 2018 shows Wye stock populations still probably at risk in 2023 with no clear trend. The disastrous catch performance of 2019 [340] and the decline in juveniles still in evidence in 2019, is likely to worsen this situation. There is no clear path currently to a reliable recovery. This proposal states clearly, a juvenile stock enhancement programme alone might not solve the problem, it needs the actions documented herein, many of which are already in train. It will however underpin stocks whilst awaiting resolution, even so we will not see first adult returnees until 2023, We need to act now, we need **'Bold and Urgent Action'.**

5. Action Summary

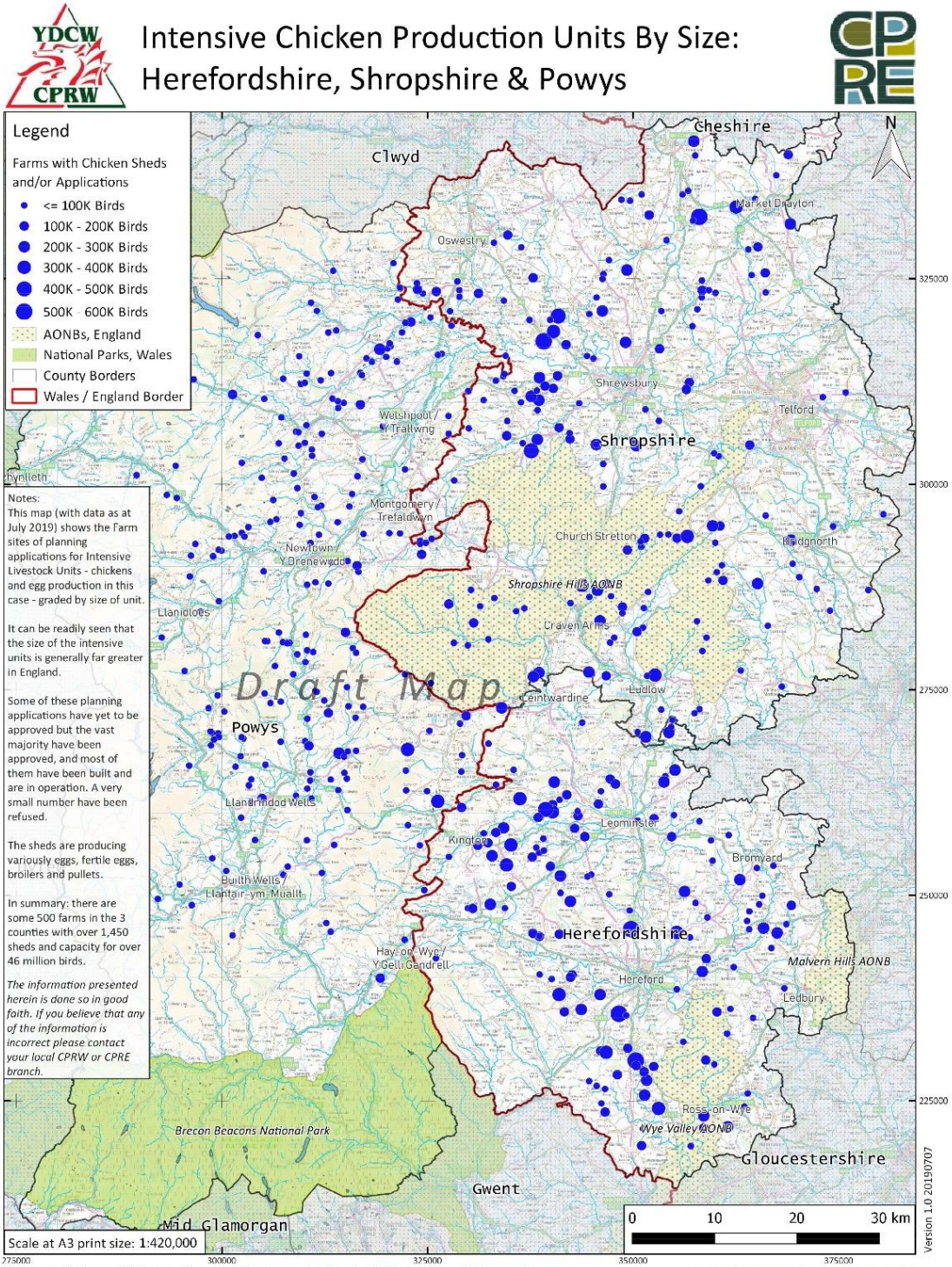
Category	Ref	Action	Provider	Deliverables
Management Process	AP1	Development of a revised WLFG structure, leadership, technical support, budgets and terms of reference for overseeing and delivery of this proposal. Impartial leadership and representative of all stakeholders (agencies, river trusts, angling clubs, owners and anglers). WLFG would be required to create momentum needed and the focus required to drive results. Its role would ensure implementation of all elements of the proposal, continuously monitoring progress and evaluating effectiveness of approach. On an annual basis report and publish formally on progress toward objectives, success of countermeasures adopted and statistical documenting of achievements with respect to conservation levels, adult and juvenile stocks, pollution levels, water quality, etc. This reporting will include a SWOT [Strengths, Weakness', Opportunities & Threats] analysis and should be subjected to peer review.	NRW	The provision of a skilled, focussed and stakeholder driven team capable of delivering project target Management Level [ML} of egg deposition. Visibility in the angling and local tourism communities of recovery progress. Accountability
Water Quality	AP2	To avoid significant ecological damage, the policy regarding how and when water is abstracted needs to be urgently reviewed, revised and then enforced. Complete reform of existing water abstraction licensing is required.	TBC	A water abstraction regime and regulation confirmed by WLFG as functioning and minimising ecological risk.
	AP3	Water temperatures are thought likely to impact severely on spawning success. Continuous monitoring in eleven spawning tributaries and including interstitial monitoring. Three years data collected. This data will be collected for another three years and will be collated with data being gathered by Cardiff University PhD student, Rowena Diamond, to form the basis of her research and reporting.	WSA	A review of results determining if they form a basis for further action within this management process.
	AP4	High water temperatures are a threat to salmon. Many owners have acted responsibly in closing fisheries. WLFG should establish an upper temperature limit and if monitoring suggests anglers/owners are not heeding advice to cease fishing should propose mandatory legislation	WLFG	A salmon fishing temperature based regime fully supported by and signed up to by owners and anglers
Habitat	AP5	The success or otherwise of habitat restoration projects can only be properly assessed after the life cycle of the salmon has been completed – usually requiring about 10 years. A full review should be held by WLFG, with providers, to establish detailed results for all completed habitat projects. Evaluate 'what worked and what didn't' in order to agree a programme of future projects to be included within this management process.	WLFG	A fourfold increase in salmon parr densities as reported by NRW Annual Salmonid Juvenile Report. 2018 = 3parr/100m2

Category	Ref	Action	Provider	Deliverables
[cont]	AP6	Re-gravelling of historical spawning areas of the Elan river appears to have been a success. Efforts should now concentrat on extending re-gravelling and bouldering [provision of bottom obstructions] to other smaller historical spawning sites.	TBC	Target =12parr/100m2
	AP7	Sedimentation/siltation of spawning gravels is now a major constraint on spawning. Many historical spawning sites have suffered badly, linked mainly to agriculture. Gravels need de-compacting by mechanical and or compressed air means in order to release areas for potential spawners.	TBC	
Barriers	AP8	A full review and assessment should be held to establish the impact of remaining barriers to down and upstream migration, identifying a list of actions to address and complete in order to agree future projects to be included in this management process.	TBC	Barrier removal prioritised by WLFG as required to support to this programme
Pollution	AP9	Phosphates considered worst polluter, currently only monitored on a monthly basis. Establish statistically valid monitoring regime reflecting the diversity of water conditions on phosphate loadings in Herefordshire and Powys sections of the rivers.	TBC	Validation of NMP reported river phosphate loadings.
	AP10	Sewage Treatment Works [SRWs] considered to produce 70% phosphate discharged to river. Establish monitoring of key STW sites and point sources. Ensuring published remedial programmes taking effect and actions are being instigated where results deteriorating.	TBC	Report progress on STWs towards compliance
	AP11	Chicken Farms. Seek clarification, and continue to monitor, that Planning Directorate instruction and NRW environmental permitting controls are; being adhered to by all planning authorities affecting Wye catchment, are proving effective in controlling situation and farm capacity thresholds are being effectively regulated by NRW.	WLFG	Planning Authorities complying with directives and permitting controls. Provision of evidence for regulatory action.
	AP12	Given the risk herbicides, pesticides and other chemicals and chemical reactions potentially pose to the salmon life cycle, establish a statistically valid monitoring regime reflecting the diversity of water conditions in Herefordshire and Powys sections of the rivers. Actions may result from collected data	TBC	Water sampling report establishing risks to salmon stocks
	AP13	Examine opportunity to commission research into chicken feed usage with lowest nitrate/phosphate discharge, plants that take up most nitrate and phosphate that can be harvested and removed from sites. Consideration to the introduction into small watercourses of plant life that takes up phosphate and nitrate, enforcement.	TBC	Opportunities to encourage phosphate reductions
Predators	AP14	Fish Eating Birds [FEBs] believed to consume 40% of smolts produced in river. Predator control must form part of any recovery plan for salmon on the river Wye, NRW should apply for and manage an Area-Based (Wye Catchment) Cormorant and Goosander Management Licence.	NRW	Control & organisation of the sensitive issue

Category	Ref	Action	Provider	Deliverables
[cont]	AP15	Create 'no fly zones', during important migration period of March to mid-May in key areas impeding and slowing smolt migration and for a significant number of cormorants and goosanders to be killed.	TBC	Reduction in high predation of juvenile salmon during growth perios and smolt runs to sea
	AP16	Support for Angling Trust in their position that FEBs should be added to the general shooting licence (along with pigeons, crows, magpies etc.).	WLFG	
	AP17	Support of all three actions above should be subject to an annual review and count of FEBs to ensure the conservation status of the birds is not threatened.	WLFG	
	AP18	Trialling and placement of a acoustic deterrent device [ADD] on the weir at Llandogo, a site regularly visited by seals.	WLFG	Reduction in loss of adult returning salmon in tidal river
Fishing	AP19	Coarse anglers use worms and barbed hooks to fish for barbel/chub in the same swims that salmon anglers use. Byelaws should be amended to reduce the risk already exposed by existing and new laws to salmon numbers. Coarse byelaws to be brought into line with salmon byelaws. Pike anglers use barbed trebles on spinners, salmon anglers cannot. Similar to previous point byelaws to be brought into line.	NRW	Uniformity, simplification in bailifing and fairness in byelaws
	AP20	An existing byelaw bans the use of maggots from March 3rd to October 17th, because they are likely to catch and threaten survival of salmon parr and smolts. Concessions are commonly given to coarse angling clubs, given current threat to salmon numbers, these concessions should be withdrawn until numbers achieve their Conservation Level (CL) on a consistent basis.	NRW	Elimination of potential source of parr and smolt mortality
Juvenile Enhancement & Monitoring	AP21	The precautionary principle is commendable, however, there is a very fine line between extreme protection and inadvertant extirpation. The stark reality is if current trends continue, it may lead to the Wye salmon becoming an endangered species. WSA urges NRW to reconsider its policy, at this point in time, and provide for a holistic approach to salmon management.	NRW	Significant increase in recorded smolt migration trends from enhancement programme as measured by smolt trapping. Adult returns >0.4% pa of enhancement fish [0.4% of circa 150,000 stock = 600]
	AP22	NRW Fishery Team to meet with WSA to agree best and most appropriate methodology and controls for implementing the juvenile enhancement programme	NRW/WSA	
	AP23	Given AP21 & 22 WSA to prepare a full juvenile enhancement programme proposal.	WSA	
	AP24	In conjunction with NRW Fishery Team, WSA to review and revise monitoring programme post agreement on detail of the proposed juvenile enhancement programme	WSA	Reporting of results of juvenile enhancement

6 Appendices

Appendix 1 – Intensive Chicken Production Units



Intensive Chicken Production Unit data prepared in good faith by Herefordshire CPRE, Shropshire CPRE, Shropshire WT and Brecon & Radnor CPRW from a) publicly available Planning Applications via the relevant County Council Planning Portals and b) Survey.

www.brecon-and-radnor-cprw.wales
www.shropshirewildlifetrust.org.uk
www.cpreherefordshire.org.uk
www.cpreshropshire.org.uk

Appendix 2 – GWCT Juvenile Enhancement Monitoring Proposal

Aims

To provide a scientific evaluation of the contribution of a salmon hatchery to the rod catch on the River Wye.

Methodology

Overview

There are now high-resolution genetic techniques that can identify the parentage of adult salmon caught by anglers. This methodology involves ascertaining, from a fin clip, the genetic identity of all broodfish used in a hatchery and the parallel construction of a genetic baseline for Wye salmon by collecting fin clips from ~500 salmon parr from throughout the catchment. The genetic signature of rod-caught fish can then be matched to either the hatchery-reared fish or resident wild fish by analysis of DNA obtained from scale samples returned by anglers. This methodology is now widely used and is much less labour intensive than marking by fin clipping thousands of juvenile salmon each year. Below is a proposed stocking/workplan schedule.

Year	First Stocking Round	Second Stocking Round	Third Stocking Round
Summer 2020	Electrofish for 500 juvenile salmon fin clips across the Wye catchment. Undertake baseline genetic analysis of these samples		
Winter 2020	Broodstock collection & genetic sampling. Eggs reared in a hatchery. Cynrig??		
2021	0+ salmon stocked into smolt release ponds in autumn	Broodstock collection & genetic sampling. Eggs reared in a hatchery	
2022		0+ salmon stocked into smolt release ponds in autumn	Broodstock collection & genetic sampling. Eggs reared in a hatchery
2023	Grilse - Anglers return scale samples		0+ salmon stocked into smolt release ponds in autumn
2024	MSW - Anglers return scale samples	Grilse - Anglers return scale samples	
2025		MSW - Anglers return scale samples	Grilse - Anglers return scale samples
2026			MSW - Anglers return scale samples
2027	Writing up		

Partnership

This work will be a partnership between the Wye Salmon Association, The Game and Wildlife Conservation Trust, Exeter University and potentially Natural Resources Wales.

Role of partners

The Wye Salmon Association (WSA) will organise the collection of brood stock with NRW (to predetermined numbers and sex ratio outlined by NRW); liaise with the hatchery at Cynrig; stock the juvenile salmon; keep meticulous predetermined hatchery and rearing records and organise the collection of scale samples from anglers.

The Game and Wildlife Conservation Trust (GWCT) will manage the project; collect samples for genetics from - 500 juvenile salmon from the Wye catchment; all broodfish used in the hatchery; ensure that samples are sent to Exeter for analysis including scales. GWCT will oversee the work of the hatchery to ensure experimental protocols are maintained and produce a draft and final report.
Exeter University (EU) will undertake the genetic analysis of the 500 juveniles, the adult broodfish used each year (Number circa 30) and all the scale samples from anglers (approximately 200 each year, 600 in total) and contribute to the draft and final reports.

Costs
GWCT @ £295 per man day
Project management & meetings – 10 man days pa for 3 years = £8,850
Collection of juvenile samples – 6 – 12 man days for 1 year = £3,540
Collection of samples from broodfish – 2 man days pa for 3 years =£ 1,770
Write interim reports and articles – 5 man days pa for 3 years = £4,425
Write the final report – 20 man days for 1 year = £5,900
GWCT Statistician for final report – 5 man days for 1 year = £1,475
Printed scale envelopes and collecting utensils for anglers - £1000
GWCT Total £26,960 + VAT = £32,352

Exeter University
Genetic analysis of 500 juvenile salmon = £11,770
DNA extraction kit (Qiagen) = 2 x 250 reaction kits = 2 x £764 + VAT = £1834
Fluidigm SNP assays (96 SNPs = £3456 + VAT) = £4147
Fluidigm SNP chips (x 7) = £2975 + VAT = £3570
Genotyping Reagent kit with Control Line Fluid (7 plates) = £1463 + VAT = £1756
Additional PCR materials (PCR master mix, Biotinium MM, ROX ref. dye) = £386 + VAT = £463

Genetic analysis of 30 adult salmon broodfish a year for 3 years (90 adults in total) = £3154
DNA extraction kit (Qiagen) = 2 x 50 reaction kits = 2 x £170 + VAT = £408
Fluidigm SNP chips (x 3) = £1275 + VAT = £1530
Genotyping Reagent kit with Control Line Fluid (3 plates) = £627 + VAT = £753
Additional PCR materials (PCR master mix, Biotinium MM, ROX ref. dye) = £386 + VAT = £463

Genetic analysis of scale samples from 200 rod-caught salmon a year (600 adults in total) = £9952
DNA extraction kits (Qiagen): 2 x 250 reactions + 2 x 50 reactions = 2 x £764, 2 x £170 + VAT = £2242
Fluidigm SNP chips (x 9 [3 per year]) = £3825 + VAT = £4590
Genotyping Reagent kit with Control Line Fluid (9 plates) = £1881 + VAT = £2257
Additional PCR materials (PCR master mix, Biotinium MM, ROX ref. dye) = £386 + VAT = £463

Staff time (+ overheads)
2-months Post-doc time (laboratory analysis, data analysis, data write-up) = **£18,603**
Report writing and project management (5 days PI time) = **£3,733**

Ancillary lab costs
Contribution to running costs of Fluidigm EP1 system = **£2750**

Exeter University Total costs = £49,962*
*Reagent prices correct as of 8/4/2019

GWCT & Exeter Costs = £32,352 + £49,962 = £82,314 over 8 years

Circa £10,289 p.a

Appendix 3 – List of Figures

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