# Semi Natural Rearing (SNR)

An Interim Report into results from the semi natural rearing of salmon smolts as part of a long term stocking strategy for the Wye.

**Abstract**

Atlantic salmon parr (*Salmo salar*) obtained from the NRW Hatchery at Cynrig near Brecon for Wye broodstock were reared in natural ponds along the river catchment. Parr placed in the ponds were able to complete their life cycle to smolting feeding on a diet of natural aquatic insects and invertebrates. Average release weights at smolting were *approximately 25% heavier than the average S1 smolt grown at Cynrig hatchery.* Parr to smolt survival in these semi natural rearing ponds was 67% compared with an expected 1 to 12% wild survival. Returning adults were monitored for fin clipping on 7 beats that caught 30.7% of 2016 season catch. Interim results suggest an adult return of stocked fish in 2016 in the range of 373 to 410 adults or 0.40% to 0.45%.



For amendments see footnotes 1 &2 [pages 5 & 6]

A voluntary partnership initiative by private individuals, WSA and NRW Cynrig Hatchery Staff. Funded by a number of owners and much volunteer resource from WSA & RWGA members. The project was created in 2011 to research the inclusion of Semi Natural Rearing (SNR) [Taylor. J 1998] of salmon smolts as part of a long term stocking strategy. SNR differed from traditional fry / parr stocking combining the advantages of hatchery technology in achieving high survival to early juveniles, with the 'real life' experiences of a wild environment protected from predation. There was substantial evidence that post release survival can be improved by increasing these 'real life' experiences.

The original report [Tyler.W, et al. 2011] suggested SNR could;

- Offer substantially better returns (from ova taken from Wye brood stock) than stocking with fry.
- Deliver high quality smolts for migration.
- Deliver high survival rates of returning adults (in the range 2 to 7%).
- Provide protection to wild smolts from predators during migration through safety in numbers.
- Provide additional spawning stock and corresponding compound growth in natural stocks.
- Improve rod catches.
- Add value to river Wye as a salmon fishery.

In October 2014 Natural Resources Wales [NRW] made a policy decision ceasing all forms of salmon stocking both from their own and third party facilities, thus ending after two years what was to be a 10 year project.

This interim report, following on from the original report produced to justify such stocking sets out to review the results so far. A final report is a still a couple of years away, once we are past the 3sw stage from the last stocking in 2015.

Fig 1: Parr/smolt stocking numbers

| Year [eg, into pond/migrate] | Pond | | | | | |
|---|---|---|---|---|---|---|
| | Nant Gwyn | Hardwick | Redbrook Farm | Caradoc | Bigsweir | Total |
| 2011/2 | 3500 | 0 | 0 | 0 | 0 | 3500 |
| 2012/3 | 3450 | 0 | 0 | 0 | 0 | 3450 |
| 2013/4 | 4000 | 13600 | 14100 | 10800 | 6500 | 49000 |
| 2014/5 | 5,200 | 0 | 13,900 | 8,500 | 10,000 | 37600 |
| | | | | | | 93550 |

## Interim Results

Dr John Taylor [Taylor. J 1998] reporting on the initial pilot study at Nant Gwyn during 2011/2 commented *'3500 fin clipped autumn parr were introduced to the pond in November 2011. The fish enjoyed foraging on natural aquatic insects and invertebrates with supplementary feeding taking place as required. The fish grew well in the pond, reaching circa 35g average weight which is approximately 25% heavier than the average S1 smolt grown at Cynrig hatchery. 60 fish were examined for data recording during the release, 59 of which had lost their parr marks and were well 'silvered'. The smolts were in very good condition with healthy fins and body condition. Protection from predators ensured mortalities were kept to a minimum with survival estimated at 97%. Approximately 3,400 smolts were released taking advantage of high water conditions in the tributaries and main stem at the end of April 2012. The trial was extremely successful in achieving its objective of producing high survival rates of healthy smolts in a semi natural environment'*

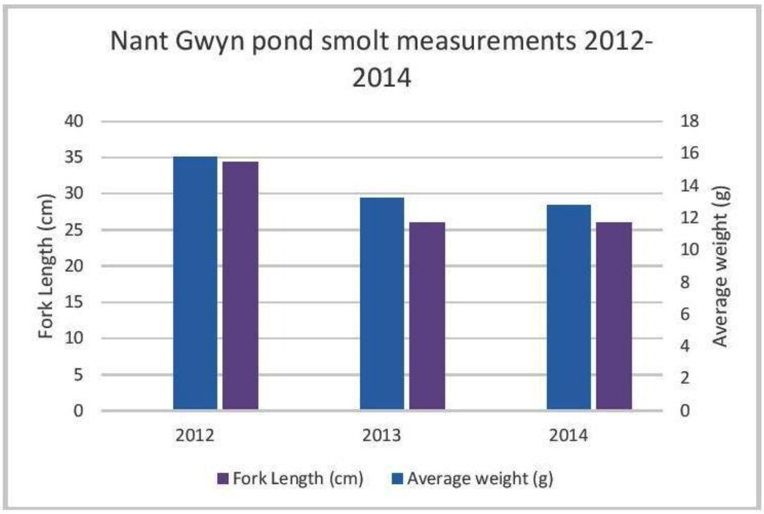

Fig 2: Data on typical parr growth

Body Condition Factor (K) is the relationship between the body weight and body length of the fish. If (K) is just below 1 it means that the fish are lean and fit. The graph above [fig 4] demonstrates that the SNR fish were in very good condition.

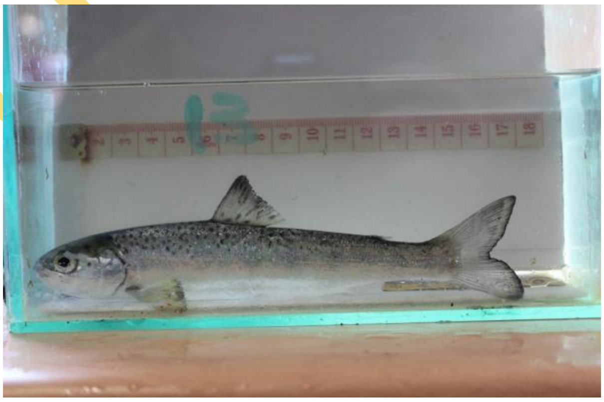
Fig 3: A Nant Gwyn smolt being measured, Note colouration, healthy fins & lean body shape

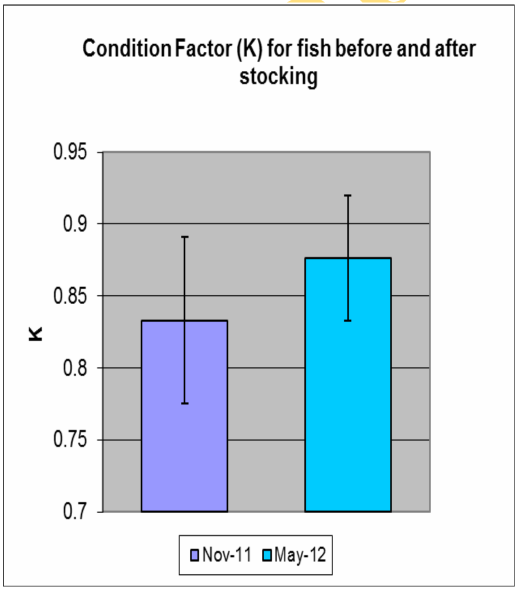

Fig 4: Body Condition factor

Subsequent monitoring by EAW/NRW team showed similar results and although in 2014 were slightly smaller than in previous years with a higher percentage of parr, Dr Taylor in his report [Taylor.J, 2015] noted *observing 'red spots and red tinges to fins, a phenomenon never observed in tank reared fish'*. Dr Taylor further commenting in his monitoring two of the other ponds in early June [Taylor. J, 2015] *'fish have been spotted migrating from the pond in recent weeks, the flow through the* *pond was excellent and conducive to migration'* and *'water quality was excellent allowing visibility throughout the whole of the pond, 25-30 smolts were counted along with 1 small parr, indicating greater than 95% of the smolts of migrated from the pond'.* Given an egg to parr survival in hatchery of 90% this would show overall survival to smolting of 85.5%, **thus offering substantially better returns (from ova taken from Wye brood stock) than stocking with fry.** [Bley, P.W., and J.R. Moring. 1988] show fry to smolt survival estimates, based on hatchery fry plantings range from about 1% to 12%. Fry to smolt survival may be a function of juvenile survival from predation and, for larger parr less susceptible to predation, competition for space. Harris (1973) reported a five-fold increase in fry to smolt survival (0.25% to 1.7%) when trout and eel predators were controlled.

A number of factors affected the results from individual ponds. Nant Gwyn was net covered and surrounded by an electric fence, effectively reducing predation to near zero. The ponds at Hardwick, Redbrook, Caradoc & Bigsweir remained unprotected with individual pond managers monitored evidence of predation, there were reports of both bird and otter presence of minor nature. Dr John Taylor suggested from personal experience with DFO Canada in Prince Edward Island that unprotected ponds could have a survival rate as low as 60%. In putting together a rough analysis of survival Dr Taylor assumed differential performance of ponds, giving an overall 67% to migration and variance in migration age and return survival as described below fig 5.

| Nant Gwyn | | | Expected Returns | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Qty | Expected Migration | 2013 | 2014 | 2015 | 2016 | 2017 | |
| 2012 | 3500 | 3325 | 79 | 5 | | | | |
| 2013 | 3450 | 3278 | | 78 | 5 | | | |
| 2014 | 4000 | 3800 | | | 90 | 6 | | |
| 2015 | 5200 | 4940 | | | | 117 | 7 | |
| | | | | | | | | |
| | Hardwicke | | | | | | | |
| 2014 | 13600 | 1360 | | | | 20 | 20 | |
| | | | | | | | | |
| | Redbrook | | | | | | | |
| 2014 | 14100 | 7050 | | | | 63 | 148 | |
| 2015 | 13900 | 6950 | | | | 63 | 146 | |
| | | | | | | | | |
| | Caradoc | | | | | | | |
| 2014 | 10800 | 9720 | | | 73 | 204 | | |
| 2015 | 8500 | 7650 | | | | 57 | 161 | |
| | | | | | | | | |
| | Bigsweir | | | | | | | |
| 2014 | 6500 | 5850 | | | 44 | 123 | | |
| 2015 | 10000 | 9000 | | | | 68 | 189 | |
| | | | | | | | | |
| | | TOTAL | 79 | 83 | 212 | 721 | 671 | 0 |

Fig 5: Nett Migration & Expected Adult Returns from Ponds

Basis of fig 5;
Nant Gwyn - 95% survival to migration, 95% S1 surviving to return at 2.5%, 5% S2 return at 3%. Hardwicke - 10% survival (same as direct stocking) 50% S1, 50% S2, 3% survival to return Redbrook - 50% survival to migration, 30% S1's at 2.5% survival to returns, 70% S2's at 3% return.
Caradoc - 90% survival to migration, 30% as S1's survival at 2.5%, 70% as S2's , 3% survival to returns.
Bigsweir - 90% survival to migration, 30% as S1's survival at 2.5%, 70% as S2's survival at 3%.

2016 was expected to be the first significant year of return with the bulk of first full stocking in spring 2014 expected to return as 2sw fish. Anglers were asked to report any returning fin clipped adults, recording date, location, weight and gender. The recapture rates of rod-caught fish from fin clipped smolts reported in our sample sites must be considered minimum values. A campaign encouraging anglers to report showed disappointing results and anecdotal evidence from other stocking projects, on other rivers suggested, there was significant under reporting, resulting in efficacy of this method to be very poor. In the moment of capture, the excitement, given for many anglers this might be one of very few in a season, remembering to check for adipose fin clipping was the last thing on their minds. When speaking to many shortly after capture they had simply not checked. In fact a number of reports were only confirmed when observing photos provided by captor. As a result 7 beats; ,Bigsweir, Upper Bigsweir, Ingeston, Golden Mile/Sheepwash[1], Red Lion [Moccas], Caemawr and Llanthomas spread over the length of the, were asked to concentrate on checking and reporting on every fish caught. This sample size, the beats involved caught 36.7% of reported catch in 2015 seemed appropriate.

| Year | Month | Day | Beat | Weight of Fish | Gender | Life Stage | Method |
|---|---|---|---|---|---|---|---|
| 2015 | May | 31 | Bigsweir | n/a | n/a | Salmon | n/a |
| 2015 | Jul | 18 | Bigsweir | 4.00 | n/a | Grilse | n/a |
| 2015 | Sep | 24 | Upper Bigsweir | 14.00 | Hen | Salmon | Fly |
| 2015 | Oct | 8 | Upper Bigsweir | 15.00 | Hen | Salmon | Fly |
| 2016 | Apr | 24 | Upper Bigsweir | 12.00 | Hen | Salmon | Fly |
| 2016 | May | 21 | Bigsweir | 14.00 | Hen | Salmon | Fly |
| 2016 | Jun | 21 | Upper Bigsweir | 20.00 | Hen | Salmon | Fly |
| 2016 | Jun | 24 | Ingeston | 11.00 | Cock | Salmon | n/a |
| 2016 | Jun | 24 | Red Lion | 16.00 | n/a | Salmon | n/a |
| 2016 | Jun | 25 | Ingeston | 10.00 | Hen | Salmon | Spin |
| 2016 | Jun | 28 | Golden Mile | 9.00 | n/a | Salmon | Fly |
| 2016 | Jul | 16 | Bigsweir | 6.00 | Hen | Grilse | Spin |
| 2016 | Jul | 21 | Bigsweir | 6.00 | n/a | Grilse | Fly |
| 2016 | Aug | 3 | Red Lion | 6.00 | n/a | Grilse | Fly |
| 2016 | Aug | 27 | Bigsweir | 15.00 | Cock | Salmon | Spin |
| 2016 | Oct | 5 | HDAA | 6.00 | n/a | Salmon | Fly |

Fig 6: Reported fin clipped salmon catches 2015/6

[1] Report refers to '7 sample beats' but listed 8. Golden Mile & Sheepwash counted as 1 in sample

The 7 beats in our monitor sample for 2016 returned 497 of seasons catch of 1618 [30.7%] and reported 11[2] fin clipped fish. An anonymous snap survey of catches on these beats suggested at least one third of anglers on two of the beats had not checked. This plus an allowance for illegally caught fish suggested an 'unreported' capture of circa 34 to give a total fin clip catch of 45.

At Upper Bigsweir the gillie was charged with reporting and photographing every catch enabling figures to be validated. Calculation based on 2 fin clipped fish of 79 catch would indicate a total fin clip catch of 41.

Cefas/EA [Cefas/EA, 2015] in its 2014 annual report suggest stock exploitation rate by anglers to be circa 11%. On the River Bush (Ireland), Crozier and Kennedy (2001) found that rod exploitation rates of mainly 1SW fish were 10.9% for wild fish and 11.1% for ranched salmon. Whereas on the River Burrishole (Ireland) exploitation of ranched fish, again predominantly 1SW, was 10.8% (Mills and Piggins, 1983). Using 11% would suggest an adult return of stocked fish in 2016 in the range of 373 to 410 adults. At this stage it is difficult to assess if objective **of delivering high survival rates of returning adults (in the range 2 to 7**%) as bulk of 2015 smolt release would be expected to return in 2017 or later as MSW fish. An assessment of interim performance, removing 1SW [Grilse] from 2016 reported and including 2015 reported, shows an extrapolated recapture rate in the range of 0.4% to o.45%.

Anecdotal evidence suggests runs of salmon after Oct $17^{th}$ [end of salmon season on Wye] are increasing. As our only method of monitoring returns is by rod catch no account can be taken of fin clipped returns post season. Studies on the Spey have suggested substantially more hatchery fish than wild are caught in post season broodstock catch up. Dr John Taylor reviewing our programme and considering this run timing suggests the reporting rate to be very low and believes survival could be 2 to 4 times greater.

In studies [Bley, P.W., and J.R. Moring. 1988] of Atlantic salmon from smolt stage to return as adult salmon, the estimated survival has ranged from 0% to 20%. While the return survival may be specific to a stock of salmon (Ryman 1970) or even to a river (Kanis et al. 1976), some trends can be found. Generally, investigators have found that the percentage of hatchery smolts returning are significantly lower than for wild smolts from the same river systems. In Ireland, Piggins (1979) concluded that 3.6 wild smolts returned for every 1 hatchery smolt. Isakson (1979) also found similar results in Iceland (2.8 wild: 1 hatchery smolt). In the western Atlantic, Baum (1983) found a range of sea survivals for Green Lake smolts to be 0.24%-1.39%, while Watt (1986) estimated wild smolt survival to adult as 3% to 8%. An experiment to improve hatchery smolt viability in the sea by training hatchery smolts in stream tanks [perhaps similar to SNR] showed some improvement in sea survival (Wendt and Saunders 1973), but it was not a significant improvement.

The question as to whether this project artificially increased the ongoing smolt run and or improved the chances of survival for wild smolts is as yet unproven. Simply because monitoring has not taken place. Whilst behavioral capabilities in SNR



[2] Sample beats caught 11 fish not 12 as originally reported. $12^{th}$ fish was caught at HDAA not in sample and not included in calculations.

reared fish were improved in a number of ways by; including minimal use of artificial [>6%], providing natural foods & feeding and mitigation of rearing & transport stress, it seems that semi naturally reared smolts living under sheltered conditions before release and lacking exposure to predators or predatory stimuli, among other factors, resulted in poorer ability to recognize and escape predators than wild fish (Olla et al., 1998; Dieperink et al., 2002), so suffered greater predation. Aprahamian et al [2003] suggests even short term exposure to semi natural conditions can increase survival by up to 5 times when compared to direct release. Wild fish may also be better able to respond to changing and sub-optimal natural conditions (Saloniemi et al., 2004). Proving this would clearly be difficult without expensive micro tagging and a smolt trapping.

The early closure of the project prohibited a review of these results being used to develop and implement an improvement plan. Providing artificial predation stimuli and experience of a wide variation in habitat, flows, currents and depths [Taylor. J, 1998] could have narrowed the survival gap [Isakson 1979] to that of wild smolts. Provision to develop a pond with such capabilities was included in original our project [Tyler. W et al 2012] and a location had been identified.

Fig 7: A study of and comparison with wild smolt production

| Source | Av'ge Catch | Exploit'n rate % | Breeding stock | Ratio Hens % | Resulting Hens | Average eggs/Hen | Total Egg Deposit | Survival to Parr % | Total Parr | Surval to Smolt % | Total Migration | Post smolt Survival % | Return Adults |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | [2] | | | |
| Wild | 870 | 11 | 7909 | 50 | 3955 | 6000 | 23727273 | n/a | n/a | 1.50% | 355909 | 3.00% | 10677 |
| Hatchery SNR [1] | n/a | n/a | 35 | 50 | 17 | 6000 | 103944 | 90 | 93550 | 67.00 | 62679 | **0.52%** | 327 |
| Hatchery SNR [1] | n/a | n/a | 21 | 50 | 10 | 6000 | 62167 | 90 | 55950 | 67.00 | 37487 | **0.87%** | 327 |
| | | | | | | | | | | | | | |

Notes

[1] Post smolt survival rates show a range using hatchery output 2012 to 2014 as lower limit and 2012 to 2015 as upper limit

[2] An Evaluation of the Survival of Atlantic Salmon (Salmo saldr L.) Fry Stocked in Eight Streams in the North West of England, M.A. Farooqi and M.W. Aprahamian, July 1995

Estimates of egg to smolt survival from both natural production and plantings range from 0.45% to 3.0%. As with fry-to-smolt survival, egg-to-smolt survival is probably a function of juvenile mortality of the overwintering eggs which is a result of density-independent environmental factors (scouring, low water, silting, etc.). Symons (1979) suggested that egg-to-smolt survival can range from less than 1% (4+ or older smolts at low juvenile survival rates) to 11% (1+smolts at high juvenile survival rates). Rarely does one find an 11% egg-to-smolt survival in nature. Infact, Meister (1962) found only 8.9% survival of 1+ parr to 2+ and 3+ smolts (5.3% survival of 0+ parr to smolt). Elson (1962) found that percentage survival to smolt decreases with smolt age (0.96%-1.44% for 2+ smolts versus 0.38%-0.58% for 3+

Fig 8: A prime 15lb fin clipped returnee

smolts) in the Pollett River, New Brunswick. However, in the Northwest Miramichi River, egg to 3+ smolt survival was 2.4% when virtual egg deposition was at an optimum value of 61/100 m2 (Paloheimo and Elson 1974).

Farooqi,M.A & Aprahamian,M.W [1995] making a case for hatchery rearing, proposed 100,000 eggs reared to fed fry and released to streams would produce 208 returning adults, a rate of 0.20%. Suggesting the same number of eggs laid in the natural environment would result in 81 returning adults, rate of 0.08%.

**Interim Conclusion**

SNR exercise having produced a gross return of 373 to 410 adults to date, has by this measure resulted in a net gain to the river in the range of 292 to 329 adult fish.

- **Providing additional spawning stock and corresponding compound growth in natural stocks.**
- **Increasing the spawning output by at least 400,000 eggs this year alone.**
- **Improving rod catches and adding value to the river Wye as a salmon fishery.**
- **Greater predation on the SNR smolts may also have reduced the predation on the wild smolts, providing a double win.**

Dr John Taylor, reviewing results suggested this could feasibly be a large underrepresentation of the actual benefits. SNR fish were part of a crop of juvenile fish produced at Cynrig Hatchery, many thousands of which were stocked to Wye feeder streams at a documented survival rate of 17% minimum to 1+. Thus there were likely to be many hundreds of potentially unclipped hatchery returnees over this period from direct stocking. See Fig 9 below. When included Dr Taylor suggests it probable the hatchery added 600+ fish to the run in 2015 and over 1000 in 2016 and 2017

| Year | Survival to 1+ Parr | Survival to S2 Smolts | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| 2009 | 78000 | 13260 | 66 | 127 | | | | | |
| 2010 | 8000* | | 80 | 80 | | | | | |
| 2011 | 156600 | 26622 | | | 133 | 255 | | | |
| 2012 | 99422 | 16901 | | | | 84 | 162 | | |
| 2013 | 183243 | 31151 | | | | | 156 | 299 | |
| 2014 | 90121 | 15320 | | | | | | 77 | 147 |
| | | | | | | | | | |
| | | | | | | | | | |
| | stocking - mean survival to 1+ 17% (electric fishing) | | | | | | | | |
| | 1+ to S2 survival 30% (Aprahamina et al - minimum - could be as high as 45%) | | | | | | | | |
| | S1 survival to return = 2.5 % | | | | | | | | |
| | S2 survival to return = 4% | | | | | | | | |

Fig 9: Potential unclipped returnees

Costs and cost benefits have not been reported at this interim stage and will be dealt with in full during final reporting.

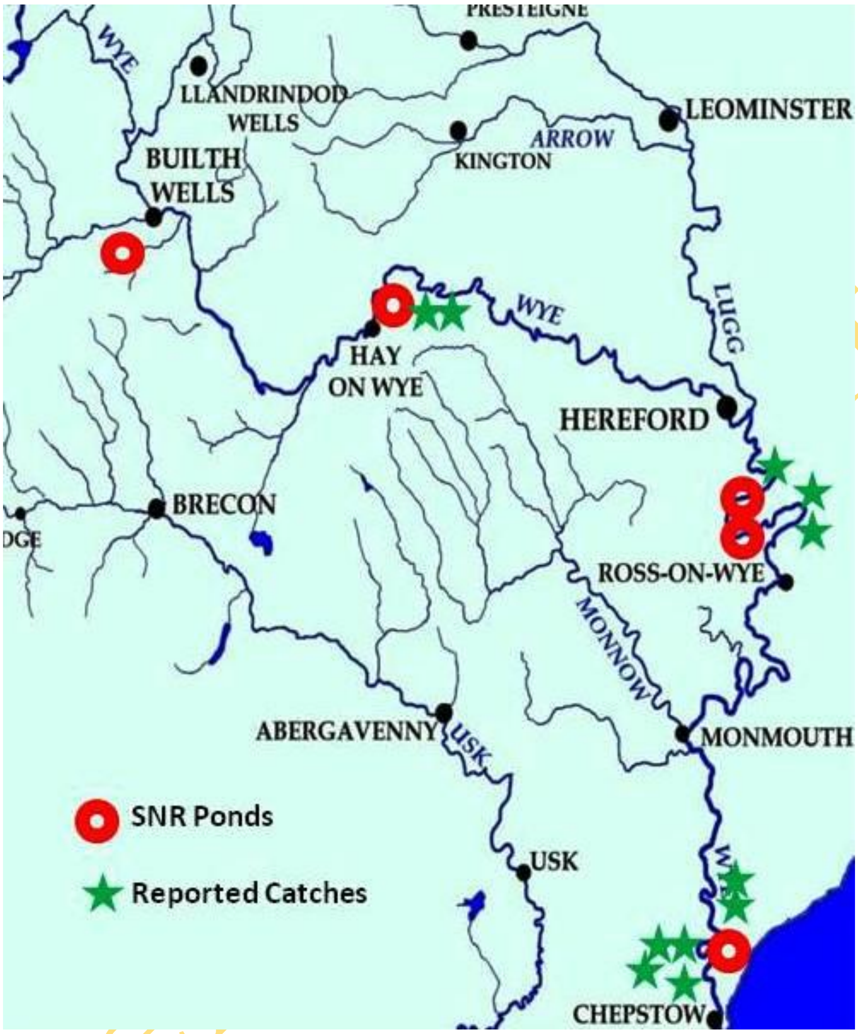


Fig 10: Pond and reported fin clip catch locations 2016

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