FAQs on HATCHERIES AND STOCKING

QUESTION: There were a lot of hatcheries in the past and there were more fish then, so why not have a hatchery on the Tweed?

ANSWER: Yes, there were hatcheries on many rivers in the past (and past catches were not as high as is often thought) but no great successes could be seen from their work, so they always remained controversial as shown in the quotations below:

The Royal Commission of 1902, after extensive investigations at home and abroad came to the conclusion: "*Reviewing generally the evidence and statistics which have been placed before us, we are forced to the conclusion that if all the circumstances are taken into account, there is no satisfactory evidence that the yield of any of these rivers has been maintained or increased by artificial hatching*"

In the *Salmon & Trout Magazine*, no. 4, 1912 in an article "*The Merits of Salmon Hatcheries",* W.L. Calderwood, listed hatcheries as having been built on the Tweed, Forth, Dee, Don, Ythan, Ugie, Spey, Ness, Beauly, Conon, Alness, Brora, Helmsdale, Thurso, Forss, Lochy, Solway Dee & Nith with a few other smaller ones elsewhere. Of these the Tweed*, Ugie, Forss and Solway Dee had been discontinued and those on the Forth, Ness & Nith had changed to mainly trout rearing

In the same magazine, in an article on Canadian Salmon and Trout fisheries; "*It may be said of all British rivers that there has been a serious shortage of salmon which began to show itself in the last half century and has gone on ever since at an accelerated pace. Attempts at artificial replenishment have not made any perceptible difference*"

The Annual Report of the Fishery Board for Scotland, 1917 said: *"The largest hatchery yet attempted with us, that of the Duke of Richmond and Gordon at Fochabers, has treated only a million eggs while a varying number of the fry have been reared to the smolt stage. After 25 years experience, this hatchery has recently been given up for want of any proof of a definite kind that benefit has resulted to the River Spey.* [There was also, however, a million-egg capacity hatchery on the Helmsdale]

An Interdepartmental (Scotland, N. Ireland, England & Wales) Committee [1] reviewed and reported on stocking in 1932. The introduction to this summed up the situation at the time "*The possibility of increasing the stock of salmon by means of artificial propagation has been a subject of <u>much controversy</u> for many years.".* This statement was made exactly 80 years after the first hatcheries had been set up and in all that time there had been no conclusive examples of stocking having increased salmon numbers. The Report therefore recommended a very large scale experiment on a river and drew up preliminary plans for this, but the work was cancelled due to government cutbacks.

The support for hatcheries in the past was based on a major mistake: the assumption that only a small percentage of eggs got fertilised during natural spawning and therefore that most eggs were "wasted" in the wild. This was not corrected till 1937, when it was found that natural fertilisation was actually highly efficient, well over 90% [2] and therefore that spawning areas were well stocked naturally and could not therefore benefit from artificial stocking.

* *The hatchery on the Tweed is referred to as having been closed. Another was subsequently opened, but closed in 1974*

THE TWEED FOUNDATION
Drygrange Steading
Melrose TD6 9DJ
www.tweedfoundation.org.uk

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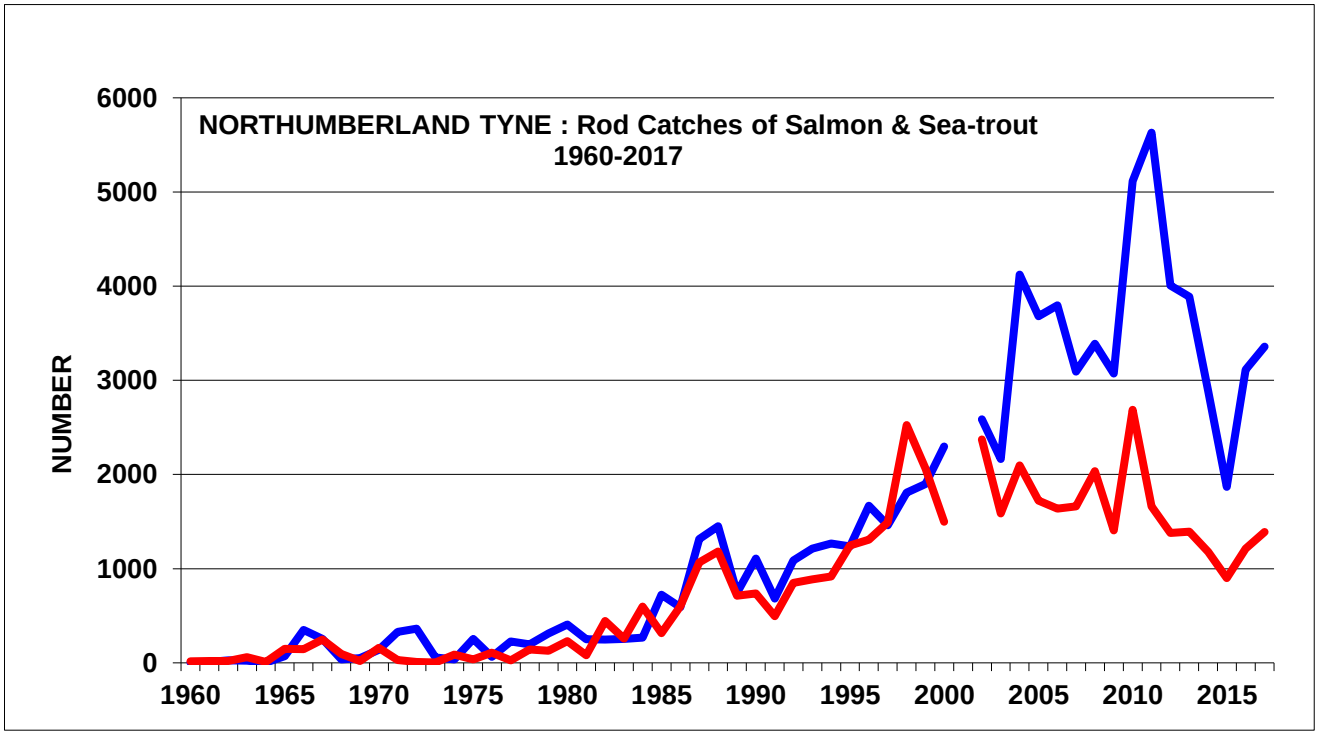
[1] The Fishery Board for Scotland 1932 No. VII *The Artificial Propagation of Salmon: A report by an Interdepartmental Committee on the need for, and possibilities of, an experiment to test its value*. Edinburgh HMSO (*)

[2] *Salmon and Trout Magazine*, no. 90, March 1938 (Editorial)

QUESTION: Even if they could not find any evidence for the value of stocking in the past are there not new techniques that would give better information now?

ANSWER: There are indeed much better ways of assessing both wild and stocked juveniles, but they still show that hatcheries are of little or no value as the recent reports listed here show:-

2008: Northumberland Tyne: http://www.ices.dk/sites/pub/CM%20Doccuments/CM-2008/N/N0508.pdf. The conclusion was that while stocking might have had some positive effects before the water quality problems in the estuary were finally overcome, the main source of the recovery of the salmon population was natural recolonisation and expansion. This is actually best illustrated by comparing the salmon and sea-trout catches of the Tyne: while salmon had an extensive and expensive stocking programme to aid their recovery, sea-trout did not – yet both recovered equally well, benefiting equally from the cleaning up of the Tyne estuary. Both species reached their capacity (either of production or of angling effort) around the year 2000, Salmon at 3-4,000, Sea-trout at 1500-2000 and numbers have fluctuated around those levels since. The highs and lows shared by both species since 2000 will be due to angling conditions in the river.



(Salmon are blue, Sea-trout, red)

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2013 R. Spey: http://www.speyfisheryboard.com/wp-content/uploads/downloads/2013/12/Spey-hatchery-final-report.pdf.

This study broke new ground in using genetics to show what contribution stocked juveniles actually made to rod catches. The broodstock used and the crosses made were genetically characterised from 2004 to 2010 and the offspring of these were looked for (1) amongst the salmon caught by anglers on the river from 2007 to 2012 and (2) amongst fish sampled below Spey Dam – as natural reproduction is low above the dam, this was an area that was heavily stocked. The results showed that the annual rod catches of salmon of hatchery origin varied from 0% to 1.8% of the total, with the best rate being 3.1% (in 2009). Of the fish trapped below the Spey Dam, none were of hatchery origin.

2014 Natural Resources Wales: : https://naturalresources.wales/media/1438/review-nrw-salmon-stocking-fish-hatcheries.pdf. The result of this review was the closure of its remaining hatcheries, with one retained for development into a research facility and an end to any further stocking by both NRW and any others in Wales, except in special circumstances.

Hatcheries have also been closed and stocking discontinued in the Irish republic

2016: Aberdeenshire Dee: http://www.riverdee.org.uk/news/2016/river-dee-hatchery-appraisal-report-published. The conclusion was that "*it is not currently appropriate to stock the Dee with Atlantic Salmon of any life history stage to enhance the fishery. The authors give several reasons for this including the risks to the wild population, the high costs of a hatchery operation and that the granting of a licence to stock salmon in the river is highly unlikely. The authors do consider that there may be scenarios where conservation stocking may be of value to protect the stocks against catastrophe. With that in mind the report suggests the Dee should have access to a hatchery for this limited purpose only*"

A more general study comparing the angler catches over 15 years in 42 English rivers that were stocked with those in 20 rivers that were not, failed to find any significant effect of the stocking. Indeed, other factors being equal, the 42 stocked rivers had lower average catches than the unstocked, with the results being poorer the older the age at which the fish were stocked. While catches in some stocked rivers did appear to improve, these still produced fewer fish than would be expected, suggesting that the stocking was damaging the wild production. The reference to this paper is:- Young, K. A. 2013, 'The balancing act of captive breeding programmes: salmon stocking and angler catch statistics' *Journal of Fisheries Management and Ecology*, vol 20 , no. 5 , pp. 434-444 .

QUESTION: More fry survive in hatcheries than in the wild. Why not rear large numbers in the safety of hatcheries and then plant them out when they are larger and better able to look after themselves?

ANSWER: Yes, more survive in hatcheries than in the wild, but it is a mistake to think that the extra fish that survive in a hatchery are worth the saving. These extra fish are those that would have lost the struggle to survive in the wild and are therefore not the sort of fish that it would be good to have to survive to breed. This is illustrated in this photo, taken of salmon fry electric-fished on the Douglas Burn in September 2009. The three large fry are being successful; they are holding territories and growing well. The small fish at the bottom is not much larger than when it emerged from the gravel in May and obviously does not hold a territory and so will die of starvation or be taken by a predator because it has no hiding place of its own. There would have been many more such unsuccessful fish earlier in the season – typically about 90% of fry die within three months of hatching as numbers "self-thin" down to the number that

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can be maintained by the available food and space. The extra fish that survive in a hatchery are these "losers" and keeping them alive only to die later when they are put back into the wild and have to fight for survival again is of no advantage and a waste of resources.

Salmon fry and parr hold territories to provide them with the food and space that they need. Stocking on top of natural populations that already fill all the available territories is pointless and a considerable waste of resources. Only if there were substantial areas upstream of total blocks to salmon migration could such stocking make any sense – and there are no such areas within the Tweed catchment.

Competition does not stop at the fry stage. As these three "winners" get larger, they will need more food and space and numbers will reduce further. This loss is not a waste or a problem, it is natural selection making sure that only the very best fish survive to breed and therefore an essential part of keeping salmon populations fit, healthy and adapting to changing environmental conditions.

There is also the problem of what hatchery rearing does to the fish that would have been the "winners" in the wild. Almost everything is changed by the very artificial conditions of a hatchery: fat content, body shape, fin size etc. and much of their behavior. The longer fish are kept under such conditions, the more different they become from wild fish and so less fit for life in the wild [1] . Hatchery rearing can therefore reduce the number of fish that survive by making the best fish less fit for life in the wild.

From time to time efforts are made to improve the quality of hatchery reared fish, but these are misguided. Most of the fish stocked out from a hatchery would have been "losers", fish that would not have survived in the wild and therefore not the sort of fish that would be wanted in a breeding population. Trying to make them better physically (their actual DNA cannot be changed*), so that more would survive to return and breed is therefore a bad idea that reduces the fitness of the breeding stock. This is because the life of the salmon is a biathlon, it has two competitions, survival in the river and survival in the sea. The breeding stock needs to be made up of the winners in both competitions. Using hatcheries to avoid the river competition altogether produces fish that are not the best for breeding – and when these cross-breed with wild stock, their poorer genetics will get back into the breeding population reducing its fitness.

*But the relative activity of different genes can be altered by the life they lead in hatcheries. These are called "Epigenetic changes". See https://www.the-scientist.com/notebook/study-finds-epigenetic-differences-between-hatchery-raised-and-wild-born-salmon-30057 for an explanation of this.

REFERENCES

[1] Scottish Marine and Freshwater Science Vol 6, no 5: *Ranching to the rod – an evaluation of adult returns from hatchery-reared Atlantic salmon smolts released in Scottish rivers*. May 2015 Available at: http://marine.gov.scot/data/ranching-rod-evaluation-adult-returns-hatchery-reared-atlantic-salmon-smolts-released-scottish

QUESTION: On the R. Ranga in Iceland, they rear smolts, bypassing all the losses of the freshwater stages, and this has produced a very successful fishery on a river with almost no natural spawning. Why not do the same on the Tweed?

ANSWER: There are many differences between salmon populations and fisheries in Iceland and in Scotland. The key one for any sort of "*put and take*" management is that in Iceland a much higher proportion of the fish in the river get caught – the estimates are from 36-85% [1] while in Scottish rivers the annual average is around 10%. [1]. For the Ranga this means that many fewer smolts need to be "*put*" into the river in order to get a good "*take*" on their return than would be the case for any Scottish river.

The salmon fishing season on the Ranga is only four months long [2] and is based on just one run-type of fish. The Tweed's season is 10 months and is based on distinct runs of Spring, Summer and Autumn fish. Any smolt ranching on the Tweed would have to take account of this structure in some way.

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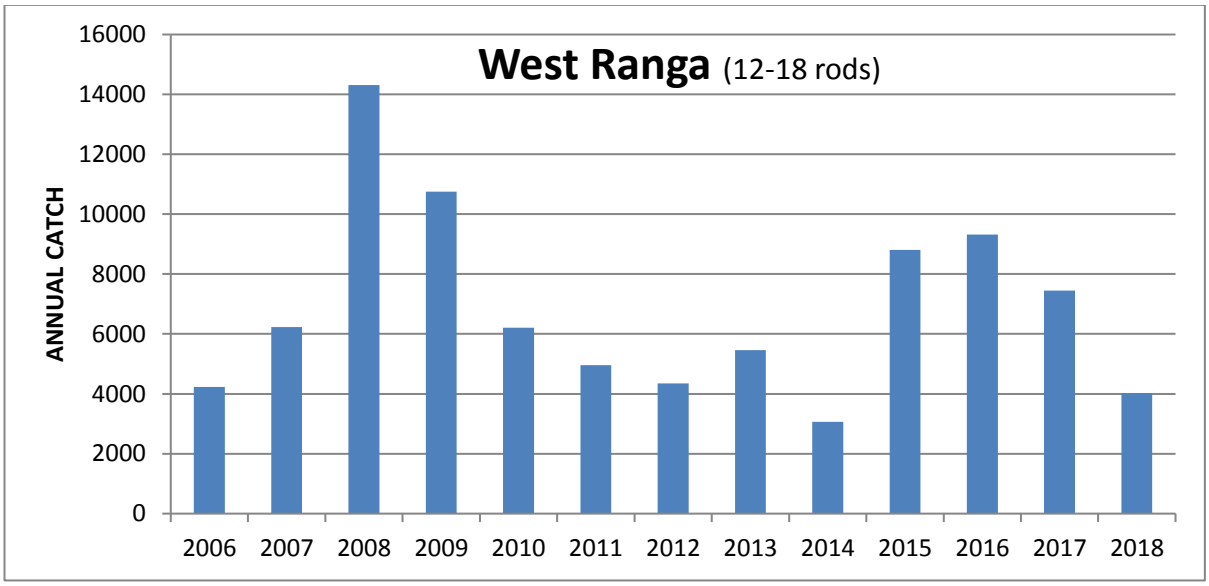
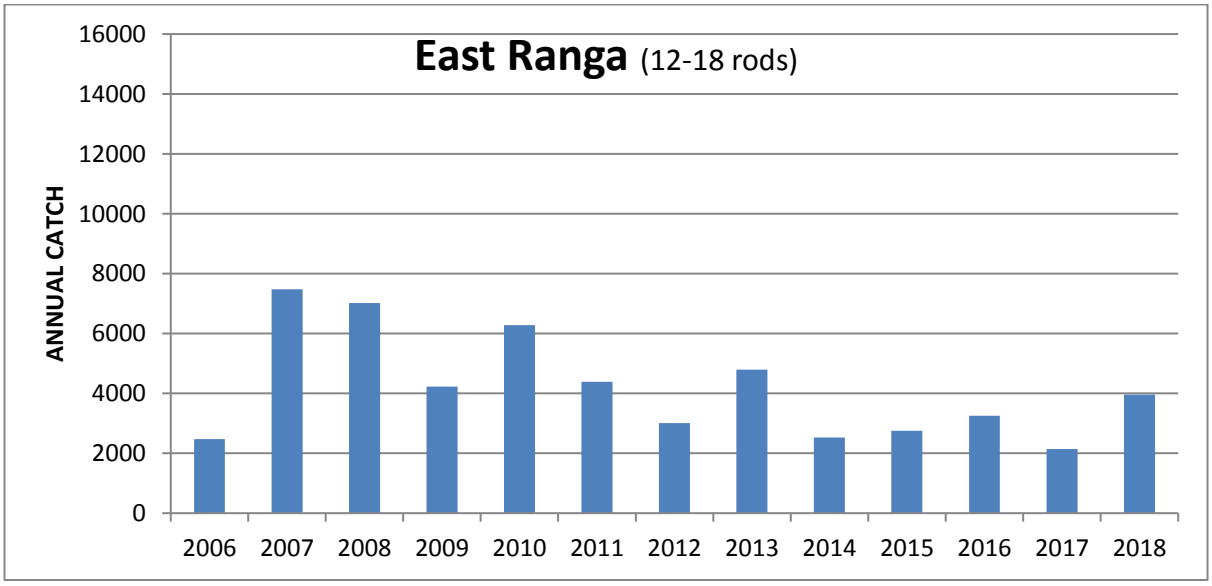
Return rates for smolts in Iceland are also better than for Scotland. This is because Icelandic fish do not have to make the long migrations that Scottish fish have to – their feeding grounds are just offshore. Recent return rates for wild Icelandic smolts are 7.9% compared to1.4% for the Ranga's hatchery smolts [3]. The return rate for wild Tweed smolts, estimated from the Gala Water smolt trap and fish counter is 4.4%, As the Ranga smolts return rate is 5.5 times worse than that of wild Icelandic smolts, if the same factor is applied to the Gala estimate, then smolts reared in the same way on the Tweed would have a return rate of 0.9%.

The West Ranga releases around a half million smolts a year at a cost of 72p each (they have the aid of geothermal water) [3]. A smolt reared on the Conon has an estimated cost of £1.50 [1]. Taking a conservative cost of £1.00 each, half a million smolts released on the Tweed would cost half a million pounds every year. From that half million, 0.9% could be expected to return to the river, 4,500 fish of which 10%, 450, could be expected to be caught. Each fish to the rod would therefore cost around £1,100 each and this expenditure would have to be made every year.

For hatchery fish to have a return rate only five times worse than that of wild fish is actually very good. The range of return rates varies from five times worse than wild, down to ten times worse [1]. At the bottom of this range, a half million smolts with a return rate of 0.45% would give 2,250 fish to the river and 225 to the rod, at a cost of around £2,200 each, every year.

Smolt ranching cannot, however, guarantee consistent returns: hatchery fish find the same conditions at sea as wild fish. Even on the Ranga, catches vary considerably from year to year as shown in the graphs below (data from: http://www.angling.is/en/catch-statistics/)





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There is also the issue of what effect hybridization between returning hatchery fish and wild fish would have. Such hybrids have a poorer survival rate than pure wild fish and the effect would therefore be to reduce wild production to some degree (and so reduce the net benefits from any smolt stocking). The very artificial conditions of hatchery rearing, even for a short time, have significant effects on the fish produced [1], which is why their return rates are so much poorer than those of wild fish. If a Tweed programme used broodstock from mixed sources (Spring, Summer & Autumn runs) then there would be the issue of returning fish of different runs spawning in the wrong parts of the river. Even if all hatchery fish were fin-clipped and so could be killed if caught this would only remove a small proportion. On the Ranga, which has no significant natural production or stock structure these issues are not relevant.

It is also of interest that though there are 80 [2] salmon rivers in Iceland, all with much smaller catches than the Ranga, only 10 have adopted the "*put and take*" approach, though not to the same extent as the Ranga and with more limited objectives [3].

The Tweed is a European Special Area of Conservation (SAC) for the salmon and management actions aimed only at increasing catches are not regarded as appropriate for a SAC and would not therefore be licenced by SNH or Marine Scotland.

REFERENCES

[1] Scottish Marine and Freshwater Science Vol 6, no 5: *Ranching to the rod – an evaluation of adult returns from hatchery-reared Atlantic salmon smolts released in Scottish rivers*. May 2015

Available at: https://www2.gov.scot/Resource/0047/00476498.pdf

[2] NASCO Implementation Plan for Iceland, 2008

Available at: http://www.nasco.int/pdf/implementation_plans/IP_Iceland.pdf

[3] Report on a fact-finding trip to the R. Ranga by the Chairman and Biologist of the Spey Board, July 2018: Available at: https://www.speyfisheryboard.com/wp-content/uploads/2018/07/Iceland-Trip-Report-250618.pdf

QUESTION: You say the catchment is well stocked naturally but how do you know what the electric-fishing results mean? How can they show that the sample sites are full to their capacity? Would there not be more fry in them if there were more spawning fish?

ANSWER: It is not the number of spawning fish that controls the numbers of fry found at electric-fishing sites, but the amount of food and quality of habitat.

Salmon fry hold home-ranges or territories that they defend against rivals and which provide them with the food and cover that they need. Fry that lose the struggle for territories either starve or are picked off by predators. This is what is shown in this photograph: three winners and a loser in the competition to hold territories and grow. The "loser" is not much bigger than when it came out of the gravel in May, but this photo was taken in September 2009 on the Douglas Burn.

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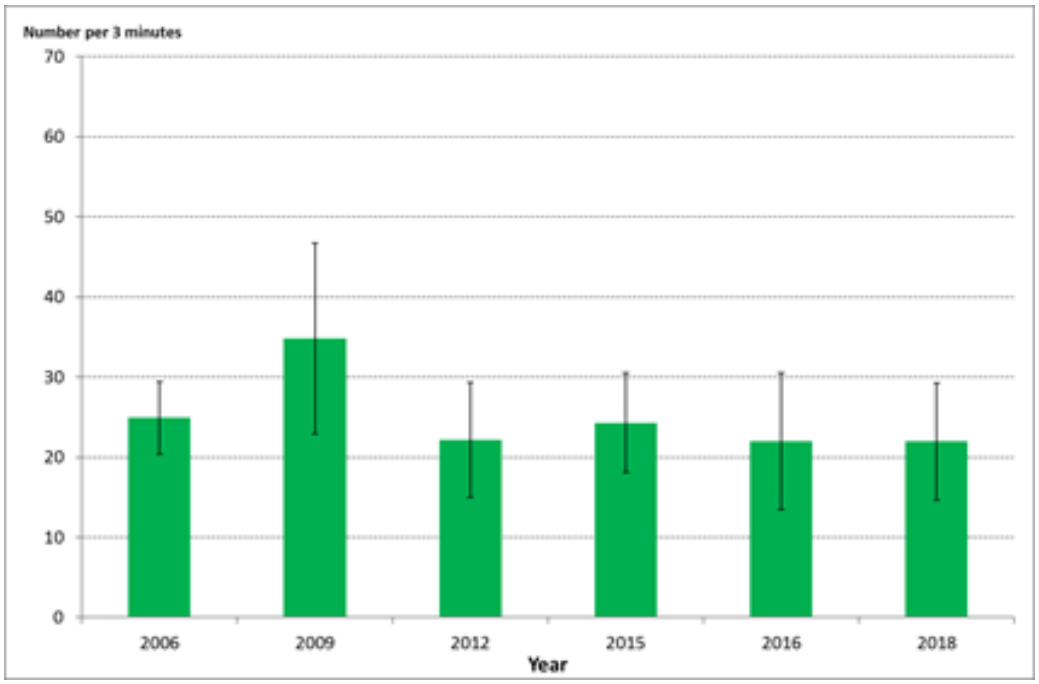
There have been many experiments in which cover was added to stream sections and was found to increase the number of fry because more territories could be held within the same area. Similar experiments adding food, usually by increasing the chemical richness of the water to increase insect production have had the same result.

There have also been "over-stocking" experiments in which larger than normal numbers of fry have been stocked into stream sections. By the end of the season though, there were the same numbers of fry left that there would have been if stocking rate had been normal. Very heavy over-stocking can actually result in fewer survivors than if stocking had been less heavy to start with, because of the extra stress and effort needed to survive.

This means that fry levels at electric-fishing sites usually stay similar over the years because the available food and space at the sites stay much the same, however much the number of spawning fish may vary. If there is food and space for 1,000 fry in a section of stream, it does not matter if there are five, ten or fifty thousand eggs spawned in it, there will be 1,000 or so fry in it at the end of the year.

These examples from the Gala and Upper Tweed show this:



Average numbers of salmon fry found on the Gala Water (19-20 sites over 5m wide)

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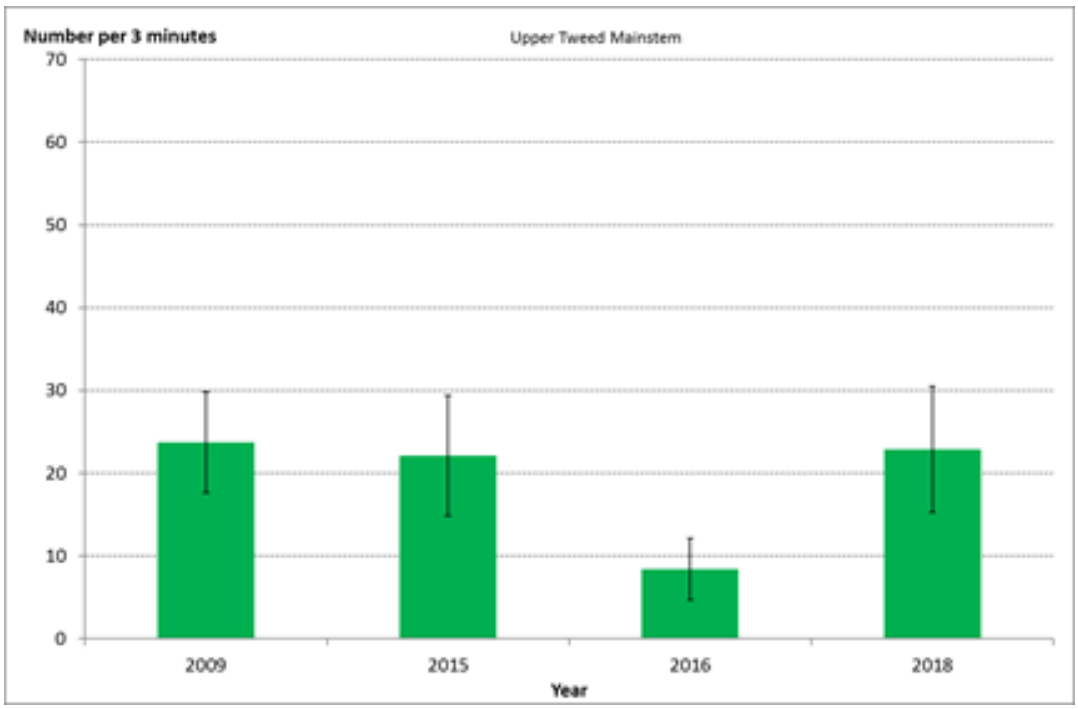

Average numbers of salmon fry found on the Upper Tweed

The bars on the columns are "*Confidence Limits*" and when these overlap it shows that there are no significant difference between averages. There are therefore no significant differences between the average numbers of fry found at sites in these two areas from survey to survey, except for the Upper Tweed in 2016, after the stormy and high water winter of 2015/16, when fry numbers were significantly down. *[NOTE: many Tweed fish smolt at only one year old, so many fry from 2016 would have smolted in 2017 and if they returned after one year at sea, as Grilse, would have been in the river in 2018. The reduced fry numbers of 2016 must therefore be a contributing factor to the poor catches of 2018].*

This stability is not surprising given the number of eggs that female salmon produce: 200 x 8lb females will give around a million eggs. It only takes a few females therefore to saturate an area with eggs and produce fry for every usable territory. Under-stocking is therefore unlikely - and higher numbers are stopped by the number of available territories.

These results are for the main channels of the Gala and the Upper Tweed where they are wide and access to spawning fish in Autumn is open and easy. Further upstream in the headwaters where access is affected by water levels results can be much more variable – and also trout begin to dominate. Results in these steeper streams can also vary due to unstable stream bottom changing the habitat between surveys. The carrying capacity (the number of possible territories) can also be reduced by problems such as siltation and this in turn will reduce the number of fry. The loss of Water Crowfoot, prime habitat for both fry and insects, from the Leader, particularly after the winter of 2015/16, reduced its carrying capacity, but this is recovering as the weed recovers.

Electric-fishing surveys in the Tweed catchment go back to the 1970s and became regular from 1992. In all that time similar levels of fry have been found except in 2016 when there were steep falls in areas where later-spawning Autumn fish breed but not where earlier spawning Spring fish come from. This was because the first storm of the very wet Winter of 2015-16 came on the 15th November after the Spring fish had spawned but in

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peak time for the later-running fish, the water remaining high for the next two months. Repeat surveys of some of these sites in 2017 found they had returned to normal fry levels.

Video clips of electric-fishing on the Tweed:

The Lilburn (Till), a Sea-trout tributary: https://www.youtube.com/watch?v=P77zKgUmXlQ

Underwater video: Upper Tweed trout burns: https://www.youtube.com/watch?v=Ira7fr3sXvw

Whiteadder trout burns: https://www.youtube.com/watch?v=hMfrY9O5nzA

Gala burns: https://www.youtube.com/watch?v=uIgnKJA92i0

QUESTION: Are there any circumstances in which artificial rearing can be of use in salmon management?

ANSWER: Yes. The most obvious is when a river has completely lost its native salmon population and has to be repopulated with fish from elsewhere. However, natural recolonization is also very effective: the R. Mersey was recolonised from the Lancashire salmon rivers to the north and the R. Seine from the Normandy salmon rivers. The closer such a river is to other salmon rivers, the quicker it can be recolonised. The Whiteadder, for example, naturally colonised very quickly after it was fully opened up in the 1990s :-

1988	7 sites, average Salmon Parr density of	0.7 per 100 m^2	(at 1 site out of 7)
1996	same 7 sites, average Salmon Parr density of	16.1 per 100 m^2	(at 6 sites out of 7)
2000	same 7 sites, average Salmon Parr density of	21.3 per 100 m^2	(at 6 sites out of 7)
2002	same 7 sites, average Salmon Parr density of	20.1 per 100 m^2	(at 7 sites out of 7)
2005	same 7 sites, average Salmon Parr density of	21.6 per 100 m^2	(at 7 sites out of 7)

The Blackadder, blocked since the 1790s had some salmon fry in its headwaters only three years after Kimmerghame cauld was eased. While salmon largely return to where they came from, it is to a length of channel that seems like “home” to them, so when a barrier is removed or eased, they can continue upstream until it no longer seems like their home area. Salmon parr, too, are migratory and are found well upstream of the furthest upstream salmon spawning.

A very interesting example of the use of hatcheries to help a river recolonise can be found on the Rhine, where fish from many different stocks, including Scottish fish, have been introduced. The aim, however, is to create stocks adapted to the various different parts and tributaries of the Rhine, so as soon as adults start returning to where they were stocked, they are used in the hatchery programme (see page 18 onwards at :

https://www.iksr.org/fileadmin/user_upload/DKDM/Dokumente/Fachberichte/EN/rp_En_0148.pdf) It is accepted, though, that the Rhine will never be able to carry the same number of fish as in the past, so much of its habitat having been flooded by dams or otherwise destroyed.

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Another example of the use of artificial rearing is in increasing the numbers of a breeding stock when it has fallen too low to produce enough eggs to stock its home area. This can be done by “reconditioning” kelts: holding them in tanks after treating them for fungus, feeding them up till the next breeding season and then stripping them for eggs, which can be done several times. Alternatively, smolts can be caught and then reared up to maturity in tanks (salmon do not have to go to the sea to become mature). In both cases, the resulting eggs are planted back into their home areas to allow natural selection to do its work and produce healthy fry.

It may be that as life at sea becomes more and more dangerous for salmon, more programmes using such captive broodstock may appear.

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