River Ayr Salmon Egg Survival Trial 2011

Water of Fail, viaduct trial site

Ayrshire Rivers Trust

Disclaimer This report has been prepared by the Ayrshire Rivers Trust on the basis of information believed to be accurate. However, the Trust does not accept any responsibility for the actions of any parties occasioned by their reading of this report. The information and images presented remain the property of the Ayrshire Rivers Trust and should not be reproduced without permission

Introduction

Ayrshire Rivers Trust (ART) carries out electrofishing surveys across Ayrshire including surveys on the main channels of the rivers supporting salmon populations to investigate salmon fry numbers (ART 2005-2010). A consistent finding over the years has been the relatively low numbers of salmon fry in the lower River Ayr. This is despite there being extensive areas of suitable spawning and juvenile habitat.

Salmon are known to spawn in good numbers in some of these areas; the gravel beds downstream of Tarholm Bridge are a good example when approximately 30 salmon redds can be seen in a typical winter. During thirty two electrofishing surveys at ten sites in the lower river Ayr downstream with the confluence with the Lugar Water, over a six year period, only two of the results was higher than D-class, i.e. in the bottom 40% of results, in the Ayrshire timed survey salmon fry index. Given that the habitat looks superficially suitable and that salmon spawn in the area, the question is why are there not more abundant numbers of salmon fry?

The lack of salmon fry in the lower river Ayr is considered by ART to be a factor limiting the productivity of the Ayr salmon population and fishery. Investigating the reasons for the low salmon fry numbers in the lower reaches of the River Ayr is a high priority for the Trust. It should be stated that it is not only the lower reaches of the Ayr which has low salmon fry numbers. The limited data we have from the Irvine suggests the situation is the same there and the fry numbers are also highly variable in the lower Girvan. In contrast the Doon and Stinchar generally support high salmon fry numbers even in the lower reaches.

The hypothesis is that survival of salmon eggs in natural redds, through the incubation period, in the lower Ayr is poor. The reasons for this are likely to be related to low oxygen levels within the gravels, possibly due to impact of siltation and water quality problems.

In order to investigate this ART carried out an egg survival trial over the course of the 2010/11 winter with newly fertilised but water hardened salmon eggs placed in vertical stacks in artificial redds. This report details the methods used, results and concludes with a discussion.

Materials and methods

Ayrshire Rivers Trust investigated egg survival at five sites in the Ayr catchment the River Ayr. At each site two vertical stacks were buried in the gravel to check consistency of results. The vertical stacks consist of circular plastic cells which can be screwed together. The cells walls were drilled or perforated to allow water to flow through. 25% of the surface area of the cells containing the eggs was drilled to match natural gravel porosity (MS ref). The cells containing eggs were lined with 1 or 2mm plastic mesh to prevent the eggs from blocking the holes and to retain any hatched alevins. The intermediated cells had fewer holes and were unlined.

Figure 1: Close up view of the stackable cells used in the egg survival trial

Into each of the egg cells 20 fertilised eggs were placed after water hardening in the hatchery. The stacks were assembled to consist alternately of six egg cells and six empty cells to provide vertical separation. The height of a complete egg stack was approximately 29cm.

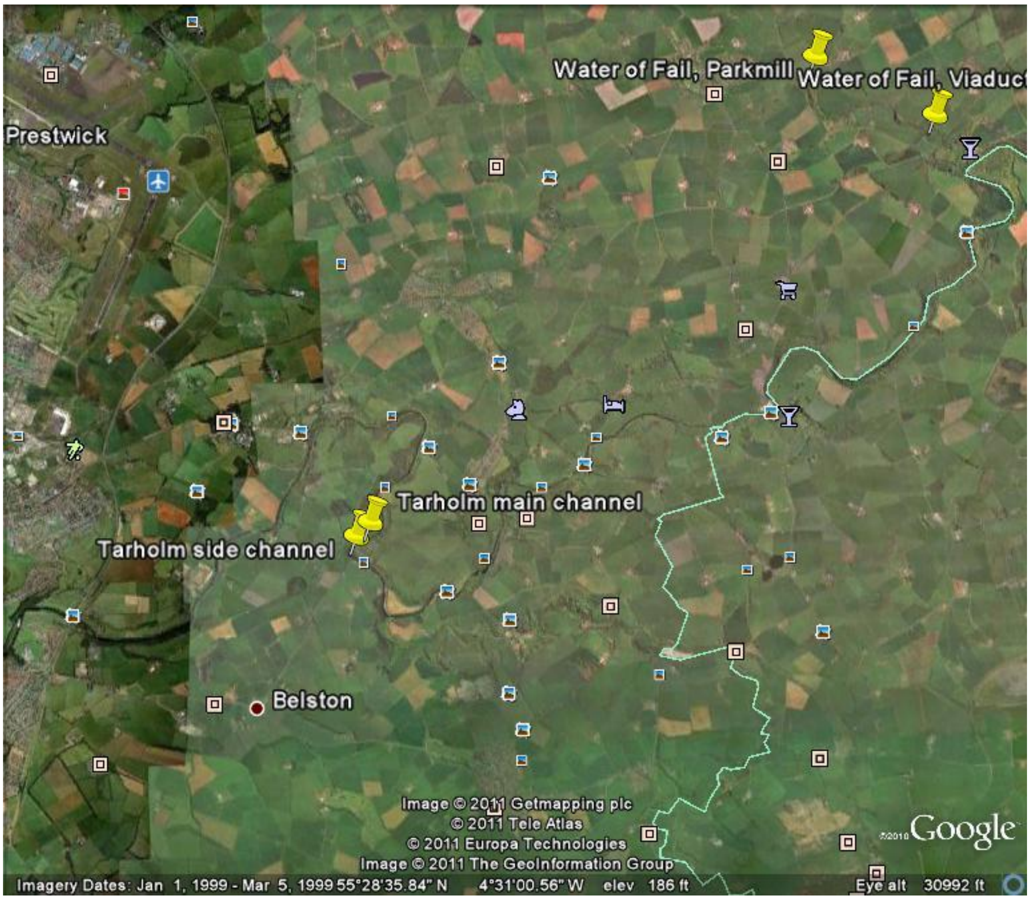
Figure 2: Completed egg stack as used in the egg survival trial

The upper cell contained no eggs but was filled with river gravel to provide ballast. The top of each stack was marked with high visibility nylon to aid relocation. At some of the sites selected it was not possible to prepare artificial redds to sufficient depth for a full height stack containing six egg cells. In that was the case the height of the stack was reduced so that the top cell was flush with the surface of the gravel. The photo below shows two of the egg stacks in situ.

Figure 3: Paired egg stacks in situ at Tarholm side channel site. This photo was taken when the stacks were removed in April and some settlement of the gravel had occurred.

All eggs were stripped on Monday 24th January 2011 am. Water hardened eggs were collected from Boreland Hatchery at 1300 and eggs stacks were put in placed in four locations that afternoon. At the fifth site, the "control site", the eggs stacks were put in place on the morning of Tuesday 25th January 2011. It should be noted that the 24th January is an unusually late date for stripping Ayr salmon. More typically the eggs held in the Boreland Hatchery are stripped at the end of the December/early January. The delay this year was due to the exceptionally cold weather experienced during December 2010.

The locations of the trial sites in the Ayr catchment are shown in the Google Earth maps below.


Water of Fail, Parkmill
Water of Fail, Viaduct
Prestwick
Tarholm main channel
Tarholm side channel
Belston
Image © 2011 Getmapping plc
© 2011 Tele Atlas
© 2011 Europa Technologies
Image © 2011 The GeoInformation Group
Google
Imagery Dates: Jan 1, 1999 - Mar 5, 1999 55°28'35.84" N 4°31'00.56" W elev 186 ft
Eye alt 30992 ft


Netherwood
Muirkirk
Muirkirk control site
Image © 2011 Getmapping plc
© 2011 Tele Atlas
Google
Imagery Dates: Jan 1, 2004 - Mar 4, 2004 55°30'58.55" N 4°07'22.76" W elev 698 ft
Eye alt 30992 ft

The five trial sites were on the River Ayr at Tarholm, one site in the main stem and another was in a side channel. Two sites were located in a Water of Fail, the upper site at Parkmill, and the lower upstream of the railway viaduct above Failford. The control site was in the main stem of the upper Ayr downstream of Muirkirk. The artificial redds at the Water of Fail sites were prepared in advance before the egg stacks were deployed, the other redds were prepared on the day of deployment. The Water of Fail is a lowland agricultural tributary of the Ayr. It suffers from diffuse pollution, high silt loading and currently supports a very poor salmonid population.

The egg stacks were recovered from four sites on Tuesday 19th April 2011 and from Muirkirk on the Friday 22nd April 2011. Each cell was opened individually and the number of hatched eggs recorded. In some cells dead alevins were present. They were recorded as surviving to hatching.

Results

The fertility rate in salmon eggs cannot be assessed easily until the incubation period is well advanced. Normally this is done in the hatchery when the eggs reach the eyed ova stage. A batch of eggs from the same stripping was held by ART to hatching. These eggs were shocked after collection from the Hatchery and the infertility rate of the eggs was found to be 9%. This figure was applied to each of the cells, i.e. the number of viable eggs in each cell was reduced to 18.2.

At each location paired stacks were deployed. Cell 1 is the uppermost stack; the depth of the middle of each cell is shown in the table below.

Table 1: Egg cell depth within gravel

Cell	Depth below gravel mm
1	42
2	89
3	135
4	183
5	230
6	278

The table below shows the percentage survival of the eggs to hatching in each of the stacks at the five locations.

Table 2: River Ayr: egg survival to hatching at each site.

Site	Tarholm main		Tarholm Side		Water of Fail, Parkmill		Water of Fail, Viaduct		Muirkirk, control		
Stack	A	B	A	B	A	B	A	B	A	B	
Cell	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	% hatched alevins	Ave % hatched
1	0	0	5	16	5	0	0	0	22	11	6
2	0	0	0	0	0	0	0	0	0	38	4
3	0	0	0	0	0	0	0	0	22	22	4
4	0	0	0	0	0	0	0	0	0	66	7
5	0	0	71	49			0	0	0	0	15
6	0	0	11	11			0	0			4
Average	0	0	15	13	1	0	0	0	9	27	
Site mean	0		14		1		0		18		

At two of the sites, Tarholm main channel and Water of Fail Viaduct site no eggs survived to hatching. In the Water of Fail, Parkmill site only one egg hatched, in the uppermost cell. The survival in the Tarholm side channel was better with mean egg survival of 14%. The results from this site were also the most consistent with eggs hatching in the same three cells in each stack.

The results from the Muirkirk site showed the best survival overall, although the results were highly variable. At this site the survival tended to be better towards the top of the stack with none surviving in the cell 5, the deepest cell, in either stack.

The graph below shows the mean egg survival to hatching in each stack. Cell 5 had the best mean survival although this was due to good survival at the Tarholm side channel, at the other sites no eggs had hatched in this cell. Mean egg survival was lowest in cells 2 and 6. Survival to hatching was recorded most frequently in cell 1 with 50% of those cells recording survival to hatch.

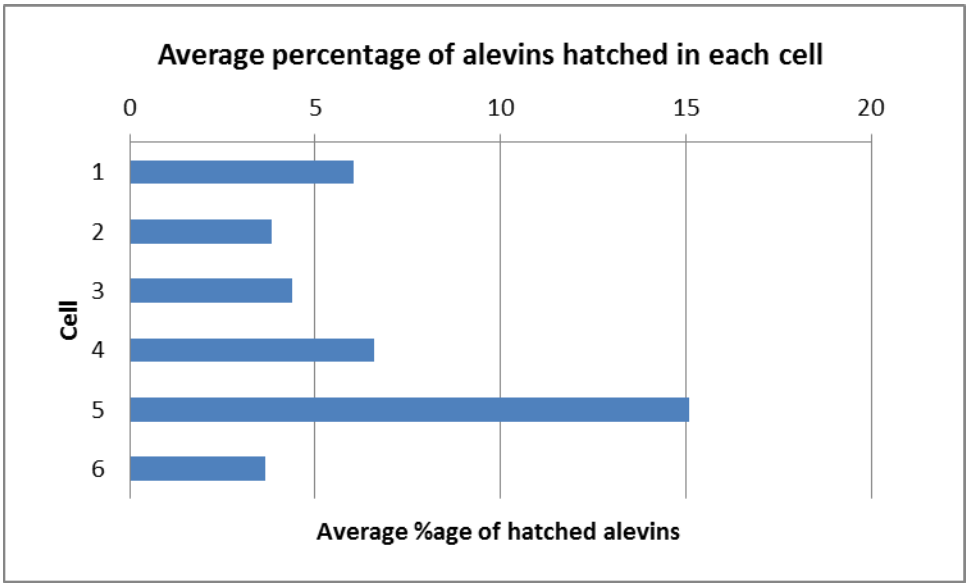


Figure 4: Mean %age of eggs hatched in each cell position

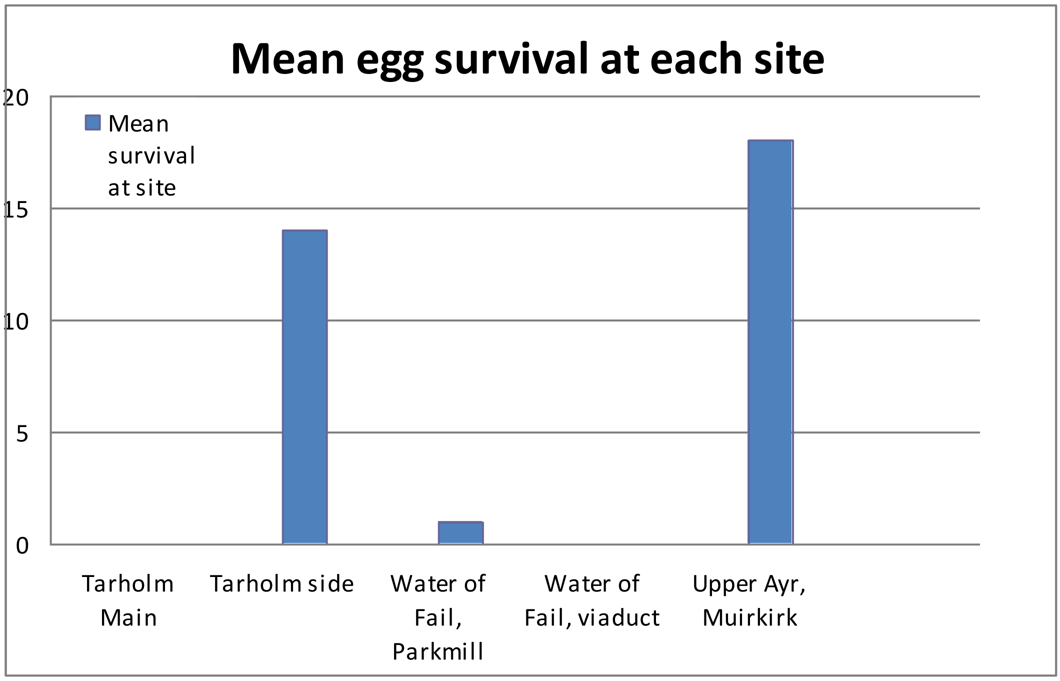


Figure 4: Mean survival to hatching at each site

The mean egg survival at each location varied greatly. No eggs survived in the Tarholm main channel site, although the survival in the side channel (an important and well used spawning channel) was the second highest. In the Water of Fail sites only one egg survived to hatch. The survival at the "control site" at Muirkirk was the highest, although only 18%.

River flows over the course of the trial were variable. In the last two weeks of the trial river flows fell to Q95 levels.

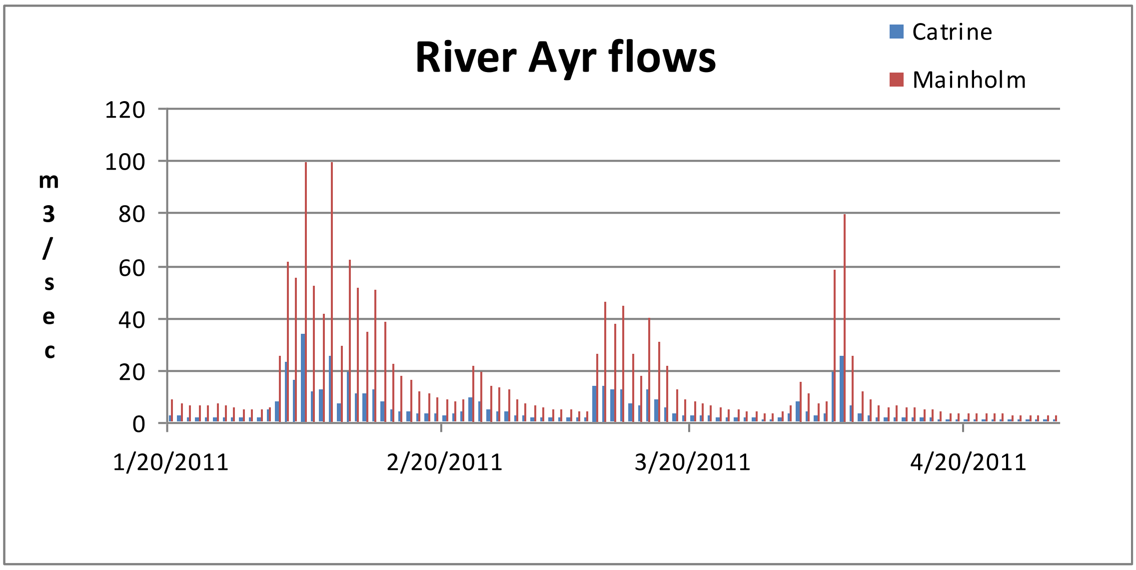


Figure 5: River Ayr flows at Catrine & Mainholm gauging stations

The appearance of the eggs and each cell were recorded when the egg stacks were removed. The upper cells in each stack were often full of sand or silt. An example of this is shown in the photo below. Silt or sand intrusion in the lower cells was much lower.

Figure 6: Cell 1 Stack 1, Water of Fail, Parkmill site. The cell was full of silt

Some of the dead eggs in the middle cells were black suggested that the conditions were anoxic.

Figure 7: Dead eggs, black in appearance. Note absence of silt from cell 4, stack 1, Tarholm main channel site

From observation of the surviving alevins they appeared to be recently hatched, probably within seven days of the end of the trial. It was noticeable that when surviving alevins were present in a number of the cells in a stack, that the alevins from the upper cells were more advanced. This may be due to greater exposure to higher surface water temperatures compared to the more stable temperatures occurring deeper within the gravel.


Figure 8: Cell 5, Stack 2, Tarholm side channel; two recently hatched live alevins are present

Many of the unhatched eggs contained well developed dead embryos and in one cell at Muirkirk a number of hatched but dead alevins were present.


Figure 9: Well developed embryos can be seen inside these dead eggs

Figure 10: These alevins had hatched but subsequently died. Muirkirk site

All live alevins were placed back into an artificial redd at each site via a pipe so that they could emerge naturally when they were fully developed.

Discussion

This study has shown that salmonid egg survival through the incubation stage in spawning gravels in the River Ayr is poor, critically so at three of the trial locations. At two of the locations survival to hatching was zero and at a third site only one alevin had hatched. Two of these sites were in the Water of Fail, a typical lowland agricultural burn which experiences high silt loading during rainfall events and generally poor water quality during low flows.

One of the sites was located in the lower main stem of the River Ayr, where the channel width is approximately 30m wide, in a location know to be frequently used by spawning salmon. The site, Tarholm main channel site, was located close to the right hand bank. At the time when the eggs stacks were removed the flow in the river was low, around Q95 and it is likely that the water exchange through the hyporheic zone at this time was also low. The location where the egg stacks were placed is a known spawning site for salmon yet zero egg survival was recorded.

Water flow through the hyporheic zone is influenced by river level (Malcolm et al., 2004). When river levels drop the hydraulic gradient which drives flow through the river gravels also decreases. It may be the case that during periods of high river flow the water exchange through the gravel is adequate to maintain oxygen levels for incubating eggs. However, during low flow periods hyporheic water exchange may be insufficient leading to egg mortality. When low flows occur during the spring, e.g. April, it will often be associated with high water temperatures and extensive epiphytic algae growth which may also restrict water exchange between the hyporheic zone and the river.

Figure 11: Tarholm main channel location. Top of one of the egg stacks is highlighted

The results from the other main stem lower river side, Tarholm main stem, were better although still only 14%. At this site hatched eggs were recorded in the top cell and in the bottom two. There was a high level of consistency between both stacks. Work carried out by Fisheries Research Services on the River Thurso using a similar methodology found that egg survival in the intermediate cells was better, the opposite of what this study found (FRS 2006). At this site the highest survival was recorded in Cell 5, at a depth of 230mm below the gravel surface.

A review of salmonid egg burial depths (DeVries 1997) found that for Atlantic salmon in typical egg burial depth for Atlantic salmon eggs was 100-230mm, from the top of the gravel mound created by the spawning salmon during redd construction. The gravel mound formed during redd completion is typically around 50mm above the general gravel level so the comparable depth for equivalent natural egg burial in this trial would be cells 1 to 4. Surviving eggs were recorded in cell 1 but not in 2-4 in the Tarholm side channel site. The best survival was recorded in cells 5 and 6, which were actually deeper than the typical deposition depth during natural spawning.

Post hatching and absorption of the yolk sac the alevins have to wriggle upwards through the gravel at emergence. Alevins deposited deep within the gravel may find it more difficult to reach the gravel surface, although this will depend on the nature of the spawning gravel. The higher survival recorded at this depth will not be of any benefit if the alevins fail to emerge once yolk sac absorption is complete.

It is difficult to explain why no eggs survived in the intermediate depths at the Tarholm side channel, at what would be considered to be the optimum depth. Further work is required to assess parameters such as oxygen levels at all depths within the gravel.

Poor egg survival in the Water of Fail sites was anticipated. Landuse within this catchment is entirely intensive agriculture, mainly dairying with some arable and beef cattle and sheep. There is also a landfill site and sewage effluent from Tarbolton treatment works. The burn suffers from high silt loadings during rainfall events and fish kills occur regularly during low water conditions. This trial shows that survival through the incubation stage is also a limiting factor.

The results from the control site, although the best in terms of overall survival were still low. In hindsight this site is far from pristine, and future work should include a control site where there are minimal anthropogenic influences. At the chosen site water quality is influenced by a number of factors upstream including Muirkirk sewage treatment works, iron rich water seepage from historic mine working and opencast mining discharges. The site was selected as it supports a high density of spawning salmon annually, a high density of salmon fry and ideal spawning gravel. There was little consistency between the paired stacks at this site, although survival was generally higher at shallower depths. Conductivity levels in this part of the river Ayr catchment are high (typically 500-700 microsiemens/cm), primarily due to high iron levels arising from surface run-off or groundwater upwelling at historic coal mining sites. Additional factors such as chemical oxygen demand chemical due to the oxidisation of the iron may have an influence on hyporheic oxygen demand. Further research is required to investigate this specific issue.

The results from this trial have confirmed that egg survival in different locations across the Ayr catchment may be a factor limiting egg survival. Further work is recommended, with more comprehensive coverage of the catchment, or even neighbouring catchments and with additional monitoring of key environmental parameters to establish the cause of the mortality.

References

Ayrshire Rivers Trust River Ayr Electrofishing Reports 2005 -2009. Ayrshire Rivers Trust, Donald Hendrie Building, Auchincruive, Ayr, Ayrshire, KA6 5HW

De Vries, Paul. Riverine salmonid egg burial depths: a review of published data and implications for scour studies. Canadian Journal Fish Aquatic Science, Vol. **54**, 1997

FRS Research Services Internal Report No. 19/06. A F Youngson, I S Maclaren & I A Malcolm. Scaling up observations of in-redd survival from tributary streams to rivers. August 2006.

Malcolm, I, A., C. Soulsby, A.F Youngson, D.M. Hannah, I.S. Maclaren & A. Thorne. Hydrological influences on hyporheic water quality: implications for salmon egg survival. Hydrological Processes, Vol. **18**, 1543-1560, 2004.

Acknowledgements

Thanks are due to Bill Menzies, River Ayr Bailiffs and the Boreland Hatchery for securing and supplying the eggs and Marine Scotland for loaning the egg stack equipment.

Thanks to the Scottish Government, via fishery management planning funding, and the River Ayr DSFB for sponsoring this project.