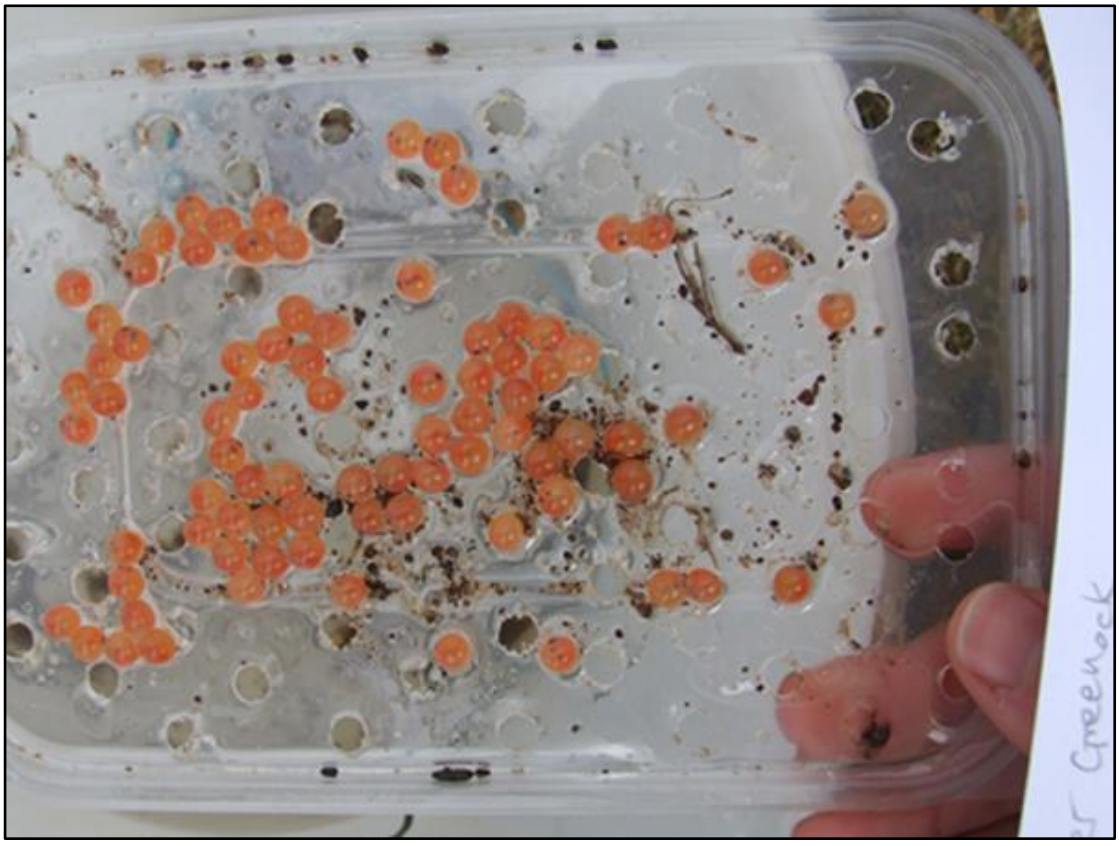
2013 Egg Survival Trial on the Ayr and Doon Catchments



Examining an egg box after 3 months in the river

Ayrshire Rivers Trust

Abstract

Ayrshire Rivers Trust (ART) undertook egg box survival trials on two catchments during the winter of 2012/13. The purpose of these trials was to determine whether salmon egg survival was compromised in key locations in both catchments.

Electrofishing results had indicated poor juvenile salmon stocks in some areas, and concerns had been raised on the upper Doon that few adult salmon were returning to traditional spawning grounds to complete their lifecycle.

There could be many reasons why adult salmon fail to spawn successfully and this study makes no attempt to quantify numbers of fish spawning in either system but merely investigates the potential for survival should eggs be deposited within the substrates by spawning salmonids.

The research concluded that enrichment from agriculture and mining activity was reducing egg survival but for different reasons.

Contents

Introduction

The River Ayr and Doon catchments are both known to suffer from diffuse pollution mainly arising from agriculture. Both catchments have also suffered from pollution arising from both historic and current mining processes and iron works. The Doon has a high proportion of plantation forestry in the upper catchment and although the Ayr has some, it is less impacted than the Doon.

The River Doon's flow is regulated by a hydro scheme that has been in place since 1936 and this provides a compensation flow of not less than 45million gallons per day. Approximately one third of the natural flow to the Doon is diverted to the Ken system in Galloway. Further to this approximately one third of the Doon catchment area is located upstream of Loch Doon Dam and only accessed by very few migratory salmonids (less than 20 per year on average) due to difficulties with fish passage. It is thought that egg survival upstream of the dam is compromised by acidic flushes from forestry during winter months.

The River Ayr catchment has been subjected to alteration for hydro power with historic modifications to the upper and middle catchment although these are currently redundant. Glenbuck Loch is artificial and was created by damming the River Ayr to create a reservoir that supplied water to the mills of Catrine. The loch remains today but serves no purpose other than for trout angling. The mills of Catrine are long gone.

Deep and surface mining has long been associated with both river catchments. Many villages developed around the deep mines and although this form of mining is no longer operational, towns and villages such as Muirkirk, Cumnock, Patna and Dalmellington remain. Current coal production continues in the form of surface mining and these communities and others benefit from the employment that is created.

Iron works featured on both catchments and blast furnace slag bings can still be seen at Waterside on the Doon and Cronberry to Muirkirk on the Ayr. Until recently, blast furnace slag was used as infill material however this no longer appears to be extracted from the bings that remain and they are now largely redundant.

The historic deep mining and iron works and more recent surface mining has all impacted water quality at times and in some areas continues to do so. Kames Colliery near Muirkirk was for many years a source of acid mine drainage but recently this was reduced by the installation of reed beds that largely remove the toxic elements from the discharge. Iron oxide still precipitates on the riverbed at Kames as leachate escapes the treatment facility resulting in deterioration of the habitat downstream. In recent years, there have been many incidents of accidental release or escape of mine water usually resulting in discoloured water and siltation. Settlement ponds are used along with chemical flocculants to remove suspended solids from consented discharges to ensure that the impact on water quality and habitat downstream is minimal. The inability of surface mines to adequately cope with high rainfall was the most common cause of these

discharges and the Scottish Environment Protection Agency (SEPA) has been actively seeking improvements from mine operators.

SEPA is the regulator responsible for ensuring our rivers are not negatively impacted by industrial and agricultural activities. They monitor and seek to improve water quality on impacted rivers through on-going projects such as the Priority Catchment Diffuse Pollution Initiative. 14 Catchments were identified as 'Priorities' for improvement across Scotland. The River Doon and Ayr catchments are amongst those identified as most in need of improvement or put another way, 'most polluted' in the country. The aim of the Priority Catchment Initiative was to return these 14 river systems to 'good ecological' status by 2015. Ayrshire has 5 water bodies included in the list of 14 Priority Catchments. Other than the Ayr and Doon, the Garnock, the Irvine and the North Ayrshire Coastal Burns are included also.

Agricultural and other inputs are targeted and many problems identified in walk over surveys, as demonstrated in figure 1. These surveys included all tributaries named on the 1:50000 OS Maps and results were summarised in a catchment wide map (figure 2) Follow up visits with landowners on a one to one basis were implemented on the Ayr catchment but have yet to be fully completed on the Doon due to staff constraints.

Figure 1: Netherton Burn where poaching by cattle leads to enrichment and siltation, reducing egg survival

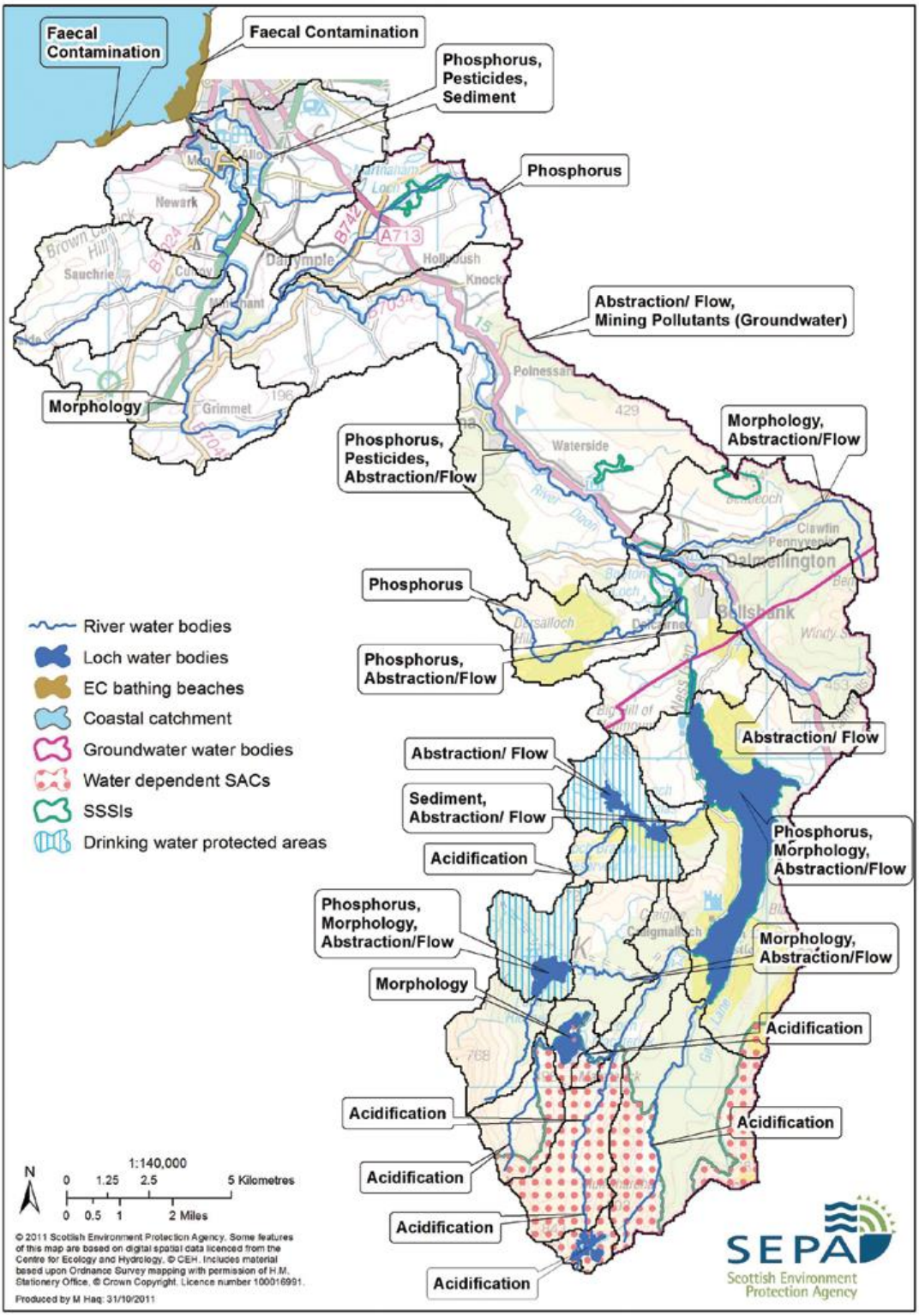


Figure 2: Summary of diffuse pollution pressures in the Doon catchment (from SEPA's Diffuse Pollution technical summary).

ART has monitored salmonid recruitment and populations on both the Doon and Ayr for the District Salmon Fishery Boards. Whilst the Ayr catchment has consistently produced poor results for several years, the Doon results are better but could be improved. No attempt has been made to determine carrying

capacity on either river and it is recognised that salmon fry populations can fluctuate widely from year to year however comparison with other rivers both locally and nationally indicates that there is scope for improvement. Indeed the results from the Ayr system over several years indicate a worryingly low juvenile salmon population in most areas. One key indicator for water body classification under the Water Framework Directive is the fish population. SEPA report that both the Ayr and Doon fish populations are classified as 'high' (with low confidence levels). ART's findings on the Ayr and in some areas of the Doon catchment refute this.

ART has recently monitored water chemistry at key locations in the upper River Ayr catchment (including the Lugar). Extremely high conductivity levels have been recorded in areas downstream of surface mining and similarly in the Doon catchment, one small burn in particular suffers from similarly high levels. Conductivity is a measure of dissolved minerals and ions present in the water. In general the greater the pollution, the higher the conductivity levels. Why discharges from working or restored surface mines are often extremely high is conjecture but thought linked to the flocculants used and minerals dissolved through the exposure of un-weathered rock. SEPA monitors discharges from mines and set strict limits on the total suspended solids permissible. They also monitor water chemistry. ART's results from the water chemistry analysis indicates high levels of certain elements in some tributaries of the Ayr and Lugar however it is not yet fully understood what impact this may be having on salmonid survival if any. Manganese levels have been found to be high; this may be influential but further research is required.

The egg box trials were designed to determine if any of the known inputs from coal mining or diffuse inputs were resulting in reduced survival during the embryonic stages. Egg box trials have been used by ART previously on the Doon to identify the cause of low productivity in Ness Glen below Loch Doon Dam. Mortality was extremely low during the trial, with egg survival found to be greater than 98%. This indicated that water quality issues were unlikely to be the cause of the low numbers of fry recorded during electrofishing surveys. Habitat was later found to be the limiting factor.

Methodology

Vibert Egg Boxes are a proprietary brand of box used for similar egg trials across the world. These boxes were not available to ART in the quantity required at the time of this study and it was decided to fabricate boxes designed to meet the requirements. ART staff made the boxes using templates to ensure that all boxes were standardised during the trial. Each box had the same number of holes in the same locations to allow water to flow through the contents.

Fertilised eggs used for the trials were stripped from brood stock collected from each river during December 2012. The eggs were mixed with milt from male salmon and fertilised following tried and tested methods. These eggs were then placed in trays to incubate in the respective hatcheries.

The River Ayr catchment eggs were stripped on the 17th December 2012. The Doon eggs were also stripped around the same date. Ideally the eggs should have been planted on the day they were stripped, as they are less fragile at that point of their development, however due to time constraints this was not possible. Alternatively they should have been left until 'hard' but this would have meant missing several weeks at a time of crucial development stages. The eggs were planted on 11th/12th January on the Ayr catchment, and 21st January for the Doon. It was decided that the eggs should be placed in boxes in the rivers taking great care to avoid knocks and bumps that could damage them. Eggs were selected from hatchery trays using a large pipette to avoid handling them. 100 eggs were placed in a zip lock bag filled with water from the hatchery. These bags were placed in a bucket of water at the same temperature and floated to prevent shocks. They were then transported to chosen sites.

Figure 3: Eggs being gently placed in a box prior to burying in the riverbed

Sites were chosen in key areas to identify whether or not there was an impact from known inputs or in areas where poor survival was expected (as indicated previously from electrofishing results). Control sites on each system were chosen to allow comparison between areas of low inputs with areas of higher or known inputs. Egg survival in the hatchery was high but the specific rate unknown.

As seen in figure 3, river gravel was placed in each box and the eggs carefully added and the lid closed. Boxes were then buried carefully in redds created in the river using a fork to loosen the substrates and ensure free flow of water

through each box (figure 4). Each box had a blue marker string attached to aid recovery at a later date.

Figure 4: Digging an artificial redd in the riverbed

On returning to collect boxes after a suitable period of incubation, the blue strings were easily located and the egg boxes carefully extracted and immediately placed into a bucket of water. The lids were opened and fine sediment and gravel removed. Surviving eggs were removed from the box then counted and photographed before being returned to the gravel to complete their incubation. All silted water from the bucket was filtered to ensure no eggs were lost. Results were recorded and are included in the results section below.

As previous trials indicated that a survival rate of between 98 and 100% was achievable for egg box trials using similar methods in good water quality conditions, ART concluded that the best results recorded could be used to determine the proportion of eggs lost due to handling and transport in their 'green' and fragile state. On both the Ayr and the Doon systems, the best results of 79% and 81% respectively were taken as maximum potential for survival (100%) in each system and this figure was used to calculate the amended percentage survival rate as detailed below in the results section.

Results

Table 1: Ayr Results

Site No	Site	Site location	River	Egg No	Date	Survived	Dead	% Survival	% survival with adjustment (79) for handling damage	Conductivity (µS)	Temp (°C)
1	U/S Avisyard	Centre of rock triangle	Lugar	99	10/04/2013	2	97	2.02	2.53	274	7.56
2	Avisyard	D/S road bridge	Lugar	99	10/04/2013	31	68	31.3	39.24	2225	9.58
3	D/S Avisyard	40m u/s conveyer,	Lugar	96	10/04/2013	missing	-	-	missing	524	7.78
4	Stottencleugh	D/s Hareshaw confluence,	Ayr	98	10/04/2013	0	98	0	0	1153	8.43
5	U/S Ponesk	Lower end of pool, above confluence	Ayr	96	10/04/2013	34	42	35.41	43.03	817	5.71
6	Ponesk	D/S road bridge	Ayr	100	10/04/2013	16	84	16	20.25	1136	8.19
7	Glenmuir Upper	Upper Gravel Extraction	Lugar	100	10/04/2013	missing	-	-	missing	153	8.63
8	Netherwellwood	D/S road bridge	Ayr	100	10/04/2013	15	85	15	18.98	604	5.87
9	Upper Wellwood	U/s road bridge	Ayr	100	10/04/2013	19	81	19	24.05	668	7.05
10	Upper Greenock		Ayr	100	10/04/2013	8	92	8	10.12	234	6.34
11	Greenock	D/S Blackside Farm bridge	Ayr	100	10/04/2013	79	21	79	100	248	6.49
12	Whitehaugh Water	U/S Greenock mains Road Bridge	Ayr	100	11/04/2013	30	70	30	37.97	290	4.48
13	Back Burn	D/s Garple Bridge, Parallel to road.	Lugar	100	11/04/2013	15	85	15	18.98	868	6.5
14	Polcalk Burn	Immediately u/s of A70,	Lugar	100	11/04/2013	57	43	57	72.15	1353	5.42
15	Lugar U/S Back Burn	u/s bridge	Lugar	100	11/04/2013	missing	-	-	missing	592	7.16
16	Back Burn D/S Polcalk	At run/riffle 100m u/s Adams Bridge	Lugar	100	11/04/2013	18	82	18	22.78	1164	5.7
17	Lugar D/S Back Burn	U/s Lugar confluence, d/s muddy footbridge	Lugar	100	11/04/2013	missing	-	-	missing	-	-

Table 2: Doon Results

Site No	Site	Grid ref Northing Easting	River	Egg No	Date	Survived	Dead	% Survival	% survival with adjustment (81) for handling damage	Conductivity (µS)	Temp (°C)
1	Mossdale	249334 604127	Doon	100	12/04/2013	81	19	81	100	82	804
2	Muck	247401 605931	Doon	100	12/04/2013	missing	-	-	missing	103	844
3	Sillyhole	247523 606439	Doon	100	12/04/2013	missing	-	-	missing	891	7.99
4	Cummock	248196 606430	Doon	100	12/04/2013	20*	60	20* or 40*	24.6* or 49.38	899	7.71
5	Dunaskin	244488 608099	Doon	100	12/04/2013	32	88	32	39.5	457	8.42
6	Boreland	240191 614062	Doon	100	12/04/2013	13	87	13	16.04	700	7.87
7	Smithston	241459 612651	Doon	100	12/04/2013	2	98	2	2.46	584	8.64
8	Netherton	237119 613665	Doon	100	12/04/2013	18	82	18	22.22	363	8.11
9	Chapleton	232624 611878	Doon	100	12/04/2013	0	100	0	0	568	7.67
10	Culroy upper	230409 614327	Doon	100	12/04/2013	10	90	10	12.34	167	7.82
11	Culroy mid	233122 614321	Doon	100	12/04/2013	1	99	1	1.23	342	8.36
12	Culroy lower	231704 614399	Doon	100	12/04/2013	1	99	1	1.23	456	8.46
13	Purclewan	236733 614808	Doon	100	16/04/2013	4	96	4	4.94	-	-

Discussion

The results from the Ayr and Doon trials are independent of each other and will be discussed separately below. Comparisons may be drawn between the two rivers and these will be discussed towards the end of this section.

During the course of the trials, survey limitations became apparent. Only one egg box was used at each location due to limited time available to ART and the limited supply of eggs from the hatcheries. At several locations, egg boxes disappeared for unknown reasons but in some locations where there was public access, it may be reasonable to assume that boxes were discovered by curious passers-by. Blue marker string may have inadvertently revealed the location of these boxes. The loss of these boxes was detrimental to the egg trials as they were designed to answer particular questions. Future trials should avoid areas where high numbers of pedestrians access. The use of marker strings could attract unwanted attention and perhaps should be avoided. It would be better to used two or more egg boxes at each location to reduce the likelihood of loss.

The River Ayr Catchment results

Lugar Water catchment

All 4 main stem boxes were lost on the Lugar side of the catchment.

The River Ayr results were on the whole very poor. The chosen distribution of the boxes was designed to monitor egg survival upstream and downstream of known inputs and also the inputs themselves.

The loss of the box from upstream of the Avisyard Burn confluence meant that the control for this side of the catchment was lost and comparison between tributary sites and further downstream with the control could not effectively be made. However, the results from the Avisyard Burn indicate that despite the extremely high conductivity results that are regularly recorded, this does not prevent the incubation and survival of eggs. Water clarity was excellent and little silt was visible although the streambed was coated with mineral deposits that appear to precipitate from the water column.

4 eggs survived and 21 alevins were found alive in the box and this equated to a survival rate of 39.24% once the adjustment was made to allow for losses through handling.
It wasn't clear how many alevins had escaped the box but given the number of dead eggs present, few were unaccounted for. With hindsight, it would have been better to count both survivors and dead eggs where alevins had hatched, however this was not always possible due to the level of decomposition.

The box downstream of the Avisyard confluence was also lost and thus no comparison can be made.

The next burn monitored downstream on the Lugar side of the catchment was the Back Burn (also known as the Ward Burn). High conductivity levels have been repeatedly recorded on this burn. It has also suffered from regular silt loading on occasions arising from a surface mine upstream. At the time of recovery, the flow through the area where the egg box was located was minimal, as water levels in the burn had reduced to a trickle due to a prolonged period of dry weather. The substrates in the burn were heavily coated with moss and algae and these trap silt. When opened the egg box was found to be heavily silted (figure 5). Egg survival after adjustment was 18.98%.

Figure 5: An egg box that was heavily silted

The Polcalk Burn also receives flow from surface mining and possibly inputs from Garlaff landfill site. Conductivity has been regularly recorded as high. At the time of recovery of the egg box, the burn appeared to be in good condition with little algal growth evident. The box was opened and although filled with fine substrates, it was not silted and survival of the eggs was recorded at 72.15% after adjustment for handling losses.

Further downstream the Polcalk and Back burn meet before joining the Lugar Water. The sampling site was immediately upstream of the confluence with the Lugar and on opening the box was silted and egg survival after adjustment was 22.78%. This was an increase from the levels recorded on the Back Burn upstream but a significant reduction from the survival rate found on the Polcalk just a short distance away.

Both egg boxes upstream and downstream of the confluence with the Back Burn/Polcalk on the Lugar were lost which meant that no comparisons could be drawn.

River Ayr Catchment

The remaining sample locations on the Ayr catchment were located on the upper Ayr and its tributaries.

The Stottencleugh Burn is the source of the River Ayr. This burn flows into Glenbuck Loch which discharges through a redundant sluice gate to the River Ayr. The Stottencleugh is affected by both current and historic mining and is reputed to receive upwelling ground water from redundant mine shafts in the area. Settlement ponds at the Ponesk and Spierslack surface mines discharge to this burn a short distance upstream of the loch. Further upstream above the current mining influences, the burn supports a healthy but isolated population of brown trout. Downstream of the mines the streambed is heavily coated with iron oxides deposited from the water column (see figure 6) and conductivity levels are high. Despite this, invertebrates can be found and late in the spawning season many trout can be witnessed attempting to lay eggs in this area. During late 2012, ART staff repeatedly witnessed new redds cut in the streambed. Egg survival in such conditions seemed unlikely hence the positioning of an egg box in this area. Once opened the box was found to have suffered 100% loss as no eggs survived.

Figure 6: Extracting the egg box from the Stottencleugh Burn

The upper reaches of the main stem River Ayr should be important areas for recruitment yet few juveniles are recorded during electrofishing surveys. The riverbed is heavily coated in algae and moss in most areas indicating enrichment. These plants trap silt and sediment, causing spawning gravels to deteriorate.

An egg box was placed immediately upstream of the Ponesk confluence where salmon were viewed prior to spawning. Once opened and the surviving eggs counted and adjusted for handling losses, the total surviving was calculated to be 43.03%.

The Ponesk Burn has recently been diverted to allow the extraction of coal reserves from below the old course of the river. Although performed to a high standard, the burn will take a considerable time to naturalise. Water quality on the Ponesk appears good although at times iron deposits and high conductivity have been recorded. The conductivity on this watercourse had dropped to low levels prior to spawning and no enrichment was obvious. A site immediately above the confluence with the River Ayr was chosen for the egg box trial. At the time of recovery, the conductivity was once again very high although no obvious explanation for this is available as the coalmine is not operational at present. Results after adjustment indicated that only 20.25% of the eggs survived.

Further downstream at Upper Wellwood, the river was in poor condition with obvious enrichment and iron oxide present across the width of the riverbed (figure 7). This area has large quantities of gravel available for spawning however the condition of the substrates are very poor hence the selection of this site for egg box trials.

Figure 7: Good spawning material in poor condition as a result of enrichment

Water levels were low and the egg box was found to be above the water line in a gravel bank. Despite this the egg box was opened and surprisingly found to contain 24.05% viable eggs. It can only be assumed that the gravel within and surrounding the box remained adequately moist and oxygen was drawn from the atmosphere. The river level had been very low for several weeks.

At Nether Wellwood the river again appeared to be in poor condition. This site is important for spawning and has been monitored by ART for several years over which a noticeable decline has been recorded in fry numbers. The egg box contained only 15 surviving eggs, which after adjustment calculated to an 18.98% survival rate. The substrates were coated with sediment and algae and the water was opaque and tinged green (figure 8), indicating enrichment.

Figure 8: Water quality at Nether Wellwood was poor

The remaining sites on the Upper Ayr system were located in tributaries. The Greenock Water is an important spawning area responsible for the majority of the recruitment that continues on the Ayr side of the catchment. Two sites were chosen on the Greenock to act as controls as this river is unaffected by current mining activity. A further site on the Whitehaugh water was also chosen as it was thought unlikely to suffer from serious agricultural pollution due to it's largely moorland character.

The lower Greenock Water site was immediately upstream of the B743 road bridge. As a control site the survival of 79 eggs was taken as 100% after adjustment for handling losses. The similar survival rate on the control site on

the Doon indicates that it is likely that the handling rate was relatively constant, and that both sported good water quality. The upper site was at Blackside Farm road bridge near the top of the sub catchment. On opening, the box contained only 8 surviving eggs, which equates to 10.12% survival after adjustment. This result was surprising and we are unsure how this can be explained. Other factors such as habitat and sediment loading appeared to be in very good condition. It is possible that handling issues may account for this result but that seems unlikely, as all eggs were handle in exactly the same manner with great care.

Finally the Whitehaugh results were disappointing. Water quality did not appear to be as good as expected and the river appeared opaque. The streambed was coated with fine algae and sediment. The site was located in the lower reaches of the Whitehaugh where agriculture is more intensive and may be responsible for the poor result. Slurry had been spread on the fields of the floodplain at some point prior to the retrieval of the egg box. After adjustment for handling losses, the survival rate was 37.97%.

The River Doon Catchment results

The research focussed on burns that were reported to lack spawning adult salmon in 2012 and also tributaries further down the catchment that are known to be underperforming, possibly as a result of diffuse pollution. Electrofishing surveys during 2013 will be able to confirm whether salmon failed to spawn in the Mossdale, Muck, Sillyhole and Cummock Burns as reported but ART felt it worth planting egg boxes in these areas at least to rule out egg survival issues as a potential cause of lack of fish returning to spawn. Of course these trials cannot assess conditions found in these areas in previous years. These burns are those most likely to be impacted by coal mining and concerns about the impact of this industry on salmonid populations are constantly debated.

2 egg boxes were lost during the course of the trial, both from important burns in the upper catchment where few fish were reported to have spawned towards the end of 2012.

To ensure that comparisons could be drawn, a control site was chosen on the Mossdale Burn upstream of Dalmellington (figure 9). The site selected was away from all external influences other than forestry. Previously, egg trials in the upper Doon catchment indicated that 98 – 100% survival was possible where water quality is good. To allow assessment of the handling impact on the eggs to be determined, the results at the control site were taken to indicate 100% survival of undamaged and viable eggs and all results from across the catchment were calculated on this basis.
81 surviving eggs were removed from the Mossdale egg box and this was adjusted to represent 100% survival after taking account of handling losses.

Figure 9: The Mossdale Burn where egg survival was excellent

Both the Muck Water and Sillyhole Burn egg boxes were missing and no further assessment of these burns was possible other than to record their conductivity, pH and temperature on the day of collection.

The egg box at the Cummock Burn was removed and alevin escaped from the box as it was lifted from the river. On opening, 20 live alevin were counted. It was noticed that a single clump of dead eggs accounted for the 60 dead eggs in the box. Fungus had apparently affected one area of the box where eggs had accumulated possibly due to the through flow of water in the box. This left 20 eggs unaccounted for and it is possible that these eggs hatched successfully and the alevin escaped the box prior to or at the time of lifting. At least two alevin were viewed escaping the box as it was removed from the water so it seems probable that the missing eggs/alevin escaped the box. In the results section 2 figures are given for the percentage survival; one using the 20 alevin present to calculate the survival rate of 24.6%, the other includes the further 20 that were suspected to have left the box to give a survival rate of 49.38%. One drawback of the custom made boxes that ART used is that alevin can escape the box and future trials would benefit from either earlier collection or the procurement of Vibert boxes that prevent alevin leaving.

Dunaskin site further downstream at Waterside was included due to its importance as a spawning burn. Unfortunately the gravel covering the egg box had been partially washed away leaving a portion of the box exposed to light. Dead eggs were visible in the exposed area prior to removal from the river. After adjustment 39.6% of eggs were calculated to have survived. Had the gravel not

been washed from the top of the box leaving it exposed, it would be reasonable to expect that improved results may have been recorded.

Smithston Burn is only thought accessible to migratory species in the lower reaches however ART decided to assess the watercourse regardless. This burn was recorded as having high conductivity both at the time of planting and at recovery. The source of this high conductivity has yet to be determined. A survival rate of only 2.46% was calculated. One viable egg and one dead alevin were found in the box. Water clarity at the burn was good and there was little evidence of silt however the riverbed was coated with algal growth indicating enrichment.

Boreland Burn also has limited access for migratory species but the lower reaches should provide good habitat for spawning. The burn downstream of the road culvert is accessible for migratory species. This area is unfenced and cattle and sheep are overwintered in the surrounding fields and have access to the burn. The streambed was covered in fined sediments and algae and the water was opaque indicating enrichment (figure 10). Egg survival was poor and calculated at 16.04%.

Figure 10: Water quality was poor on Boreland Burn

Unfenced margins at Netherton Burn allowed overwintering cattle access to this watercourse. The unrestricted access to the burn is causing substantial deterioration of the water environment. At the time of planting the burn appeared to be in very poor condition and this was later reported to SEPA for further investigation. SEPA indicated that burn was in good condition and they could find no significant pollution sources.

Salmon were known to spawn in the area of the egg trial until recently. ART intends to electrofish the burn to assess spawning success from this winter (2012/13) in the months ahead. The egg box produced a survival rate of 22.22%.

Another underperforming burn (and sub catchment) is the Chapelton Burn. ART found a single salmon fry in the Brockloch Burn during 2012. This indicates that migratory species still access the burn but probably in very low numbers. The Chapelton sub catchment has considerable potential for salmonid spawning and as a juvenile nursery but will require significant improvements to water and habitat quality. Intensive agriculture and road run off are thought to be the main factors currently limiting production however previous morphological alterations also contribute to the poor quality of the habitat. The egg trial site was downstream of the Brockloch confluence. At the time of planting, suitable substrates were impossible to locate due to the high volume of fine sediment on the riverbed. The best available habit was picked but on retrieval, the box was heavily silted (see figure 11) and no eggs survived.

Figure 11: A heavily silted egg box with poor survival

The Doon has few large tributaries and the Culroy Burn is perhaps the most significant with the greatest potential for recruitment. Until just a few years ago, the burn was regularly stocked by the DSFB with salmon and trout fry but this has failed to produce a sustainable population of consequence. There may be several reasons for this, however in order to assess egg survival, ART placed 3 boxes in the burn. The upper box was located high in the catchment at Sauchrie (figure 12). Overgrazing by sheep is obvious in this area but erosion doesn't appear to be excessive. Water quality appears to be good with a diverse range of invertebrates and virtually no siltation obvious. In such circumstances, egg

survival should be expected to be good unless other less obvious factors affect the burn. The results from the egg box were very poor at only 12.34% survival.

Downstream at Culroy, the habitat was again suitable for egg deposition and again a good result was anticipated. The result was poor with only a single egg surviving. ART has electrofished this area recently and found very low numbers of salmon surviving. The habitat provides an excellent juvenile nursery area (figure 13).

At Minishant, a further box was placed in the gravel and results once again indicated an underlying problem exists. Only a single egg survived in this location.

Figure 12: The Culroy Burn at Sauchrie

The results from the Culroy are extremely disappointing and at present unexplained. ART intend to focus considerable attention on this sub catchment in the year ahead in an attempt to identify the causes of the low survival and productivity. This sub catchment should produce many trout and salmon annually.

Figure 13: Habitat and water quality appeared good despite very poor results at Culroy

Purclewan Burn is one which bears high levels of agriculture. Although the area in which the egg box was placed is fenced high levels of silt cement the gravel bed. Only 4 eggs survived, making an adjusted survival rate of just 4.94%. A ford is present not far upstream of the site, and stock access is prominent along the course of the burn (figure 14). Unfortunately ART were unable to record conductivity or temperature on the Purclewan, which could be a high productivity burn given a little care.

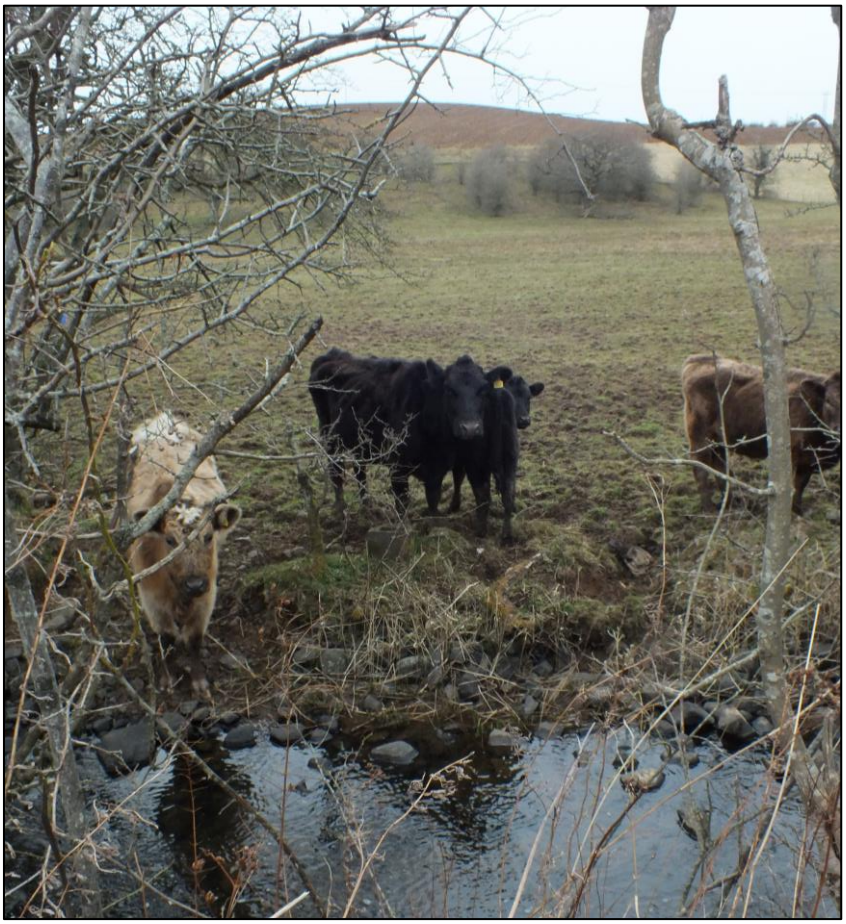


Figure 14: Cattle have easy access to the burn

Conclusions

The results gained from these trials indicate that there are serious problems for egg survival on both the Doon and Ayr catchments. The reason why eggs fail cannot be deduced from these results alone however it appears that coal mining does not impact on egg survival to the extent that was originally suspected. This study only looked at egg survival and there are other life stages that may be affected by inputs arising from coal mining.

It is clear that where silt was found in egg boxes, egg survival is compromised. As many of the survey locations suffered from siltation, egg survival from natural spawning is bound to be reduced. Agriculture is responsible for most of the poaching and erosion that leads to siltation within the Ayr and Doon catchments but not all. Mining has been linked to pollution events and frequent discharges of coloured and silted water have been reported to SEPA by ART staff in recent years on both systems.

Enrichment of both the Lugar and Ayr is obvious with the upper Ayr badly affected. Algae and moss grow on the riverbed smothering the substrates. These plants feed on dissolved nutrients and trap sediments carried in the water column. When disturbed, clouds of silt are visible. This trapped sediment and excessive plant growth reduced the quality of spawning gravels and in places leads to compaction and concretion rendering the gravel unsuitable for spawning purposes. This phenomenon was noticeable in the Doon catchment too but to a lesser extent and mainly confined to small burns in intensively farmed areas.

Mining influences leading to iron deposits on the riverbed in the Muirkirk area of the River Ayr and the Stottencleugh Burn are responsible for reducing egg survival as the gravels are thickly coated with iron oxide and in very poor condition. This also leads to enrichment and algal growth is noticeably increased in these areas and for a considerable distance downstream with the associated increase in siltation. Disturbing the substrates that are coated with iron oxide reveals that the underside of the stones are black, an indication of anoxic conditions which is linked to poor egg survival.

The Doon system is failing especially in the middle to lower reaches. The impact from agriculture is most noticeable on the Chapelton catchment where agricultural enrichment is obvious and reducing water quality. Morphological alterations are responsible for much of the habitat degradation in this area and spawning substrates are limited as a result.

The Culroy Burn has significant problems and as yet these have still to be identified. Habitat quality appears to be good on the whole although overgrazing and poaching does lead to a degree of erosion. However, this is not thought to be the most limiting factor at present and further investigation of the full system is essential to identify the underlying problems.

Failure to address these issues will lead to further reduction of fish stocks on both the Ayr and Doon catchment.

Recommendations

Reducing enrichment on both systems will rely on substantial improvement in practices by farmers and mine operators. Rapid restoration of worked surface mines would reduce the exposure of unweathered rock to the rainwater and reduce the dissolved minerals that contribute to enrichment.

Further research into the effects that mine discharges are having on water quality and habitat would be beneficial.

Key spawning areas could be improved by manual gravel cleaning immediately prior to spawning although without stricter controls on inputs, benefit arising from these actions are likely to be short lived and will require further intervention on an annual basis to maintain any improvement to fish stocks. This is likely to be expensive and require considerable input from DSFB's, anglers and other willing parties.

Long term improvement in egg survival will largely rely on reducing inputs from agriculture and mining activity. These are the main sources of enrichment identified during this research although ART recognises that there are likely to be others too such as road run off, septic tank and sewage treatment works discharges.

ART also recognises that SEPA, as the regulator are responsible for protecting our freshwater environment from pollution and they are actively addressing these problems through their 'Diffuse Pollution Priority Catchments' initiative. However, it is unclear how any significant improvement will be made by the 2015 target that has been set.

SEPA should seek further evidence regarding fish stocks in both rivers to update their classification of the status of fish in these rivers.