Ayrshire Rivers Trust

River Ayr Smolt Trap 2010

Supported by the River Ayr District Salmon Fishery Board, The Scottish Government and Scottish Coal

Smolt trap installed at Stairaird, River Ayr, March 2010

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Background

Since 2005 the Ayr DSFB has been stocking the Ayr catchment with sea trout purchased from Seafield College, Wester Ross. The success of this stocking was unknown and reported sea trout catch returns up to 2009 failed to indicate significant improvement in the numbers of sea trout returning to the river following a period at sea.

In order to investigate salmon and sea trout smolt production, Ayrshire Rivers Trust operated a Rotary Screw Trap in the River Ayr during the months of March to May 2010 in order to collect samples of the salmonids smolts descending the river. As the trap was to be located in the middle reaches, no attempt would be made to quantify the number of smolts being produced throughout the system, however all of the sea trout stocking that had taken place in previous years was upstream of the trap's position and therefore any sea trout smolt originating from the DSFB's stocking programme would pass through the trap site on their way to the sea.

Additionally, the smolt trap would provide the opportunity to sample the Ayr sea trout and salmon smolt run for genetic analysis, size and age distribution.

Aims and Objectives

The aims of the project:

- To identify the timing of both salmon and sea trout smolt runs.
- To collect genetic samples from both salmon and sea trout for future analysis.
- To identify the ages at which smolts migrate.
- To assess whether sea trout smolts are being produced in the upper River Ayr.
- To identify predator damage to smolts.

The objectives were:

- Operate the trap over a period to assess the timing of salmonids smolt runs.
- Assess the size range of the smolts trapped.
- Collect representative scale samples to provide information on smolt age profile.
- Collect genetic samples from salmon and sea trout smolts.
- Determine the percentage of trapped smolts with predator damage.
- Produce a detailed project report.
- Disseminate project findings within RAFTS and to the River Ayr District Salmon Fishery Board.

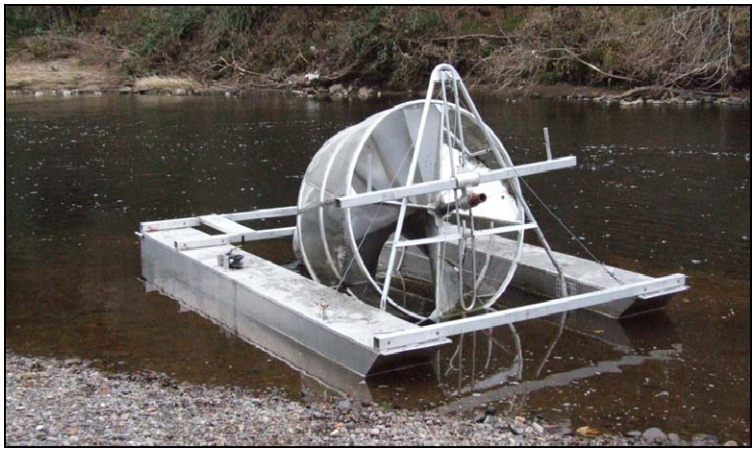
Funding

We were grateful to the Scottish Government, the Ayr District Salmon Fishery Board and Scottish Coal for providing funding for this project.

Description of a Rotary Screw Trap

A Rotary Screw Trap (RST) is a specialised fish trap designed to intercept and trap fish migrating in a downstream direction. The trap consists of a revolving conical cage, two pontoons and a tank to contain the fish. The cage revolves by utilising the force of the current against internal fins to rotate the cage around a central axis. The speed of rotation is controlled by the velocity of the current and the depth at which the drum is set in the water. Fish that enter the cage are gently funnelled downstream into the holding tank at the rear of the assembly. The working parts of the trap are suspended between two aluminium pontoons. The effective fishing area of the RST is determined by the depth to which the drum is lowered in the water.

Plate 1. Rotary Screw Trap during assembly. The rotating drum and internal fins can clearly be seen. The holding tank has yet to be attached.



Site Selection

Selecting the site at which to operate a RST is perhaps the most crucial decision relating to any trapping project. The trap requires an adequate flow of water and sufficient depth to operate. Too much or too little flow affects the speed of rotation, the ability of fish to escape the trap and perhaps also the survival rate of smolts trapped. Adequate depth is required to allow the drum to be lowered to a fishing depth for the target species.

The trap was held in position by an arrangement of anchor ropes and blocks.

Plates 2 & 3. Plate 2 (left) shows the RST in position held by ropes attached to anchors. In this photo, the river is in spate. Plate 3 shows the trap lowered to fishing position.

Methodology

The RST was deployed on the main stem of the River Ayr, 14.5 kilometres from the sea and a short distance upstream of Failford. This location was secure, accessible and proved ideal for trapping. The overall width of the river bed was approximately 32 metres at the site although most of the flow is concentrated within a 6metre wide channel. Wet width throughout most of the project was approximately 14metres.

ART obtained the use of a RST from Galloway Fisheries Trust. The trap came disassembled on a trailer and was constructed on site on the 23rd March 2010. At the same time, a JBC was used to place two concrete anchors into the stream bed to which the trap was secured. Two concrete beams weighing in excess of one tonne each were used as anchors that would not drag during spate conditions. The use of precast concrete blocks enabled their removal from the river at the end of the project.

As the River Ayr is prone to large and rapid rises in water level, the trap was rigged to allow ART staff to quickly and safely remove the trap from service and swing it into a safe position away from floating debris carried by the river.

Plate 4. The RST beached following a spate during the first week of operation. The trap had been removed from service and allowed to swing into the relative safety of the left bank.

For optimal operation, the position of the RST was adjusted by alterations to the length and angle of the anchor ropes. Due to low and consistent flows from mid April to the end of May little or no adjustment was required and the position of the trap remained constant with only minor adjustment to the depth at which the drum operated.

The chosen location enabled the trap to be fished in the main current between a sandstone shelf on the right bank and gradually sloping shingle on the left bank. The drum was lowered to within 150mm of the stream bed. This allowed the trap to fish across its width and throughout most of the water column.

Plate 5. The RST in fishing position between a sandstone shelf and gently sloping gravel deposits.

Operation

The RST operated for 24 hours a day, 55 days out of a total of 65 available between the 24th March and the 28th May. It was not operated on the 26-28th March, 30th March -3rd April and 5-7th April. The sole reason for non-deployment was high water conditions. The trap was deployed continuously between the 8th April and the 28th May.

The trap was checked twice daily, morning and evening. Leaf debris and litter built up quickly in the holding tank and had to be removed to prevent damaging fish. Trapped fish were removed and processed in the morning. Fish were very rarely caught in the trap during daylight hours.

Sampling

Fish sampling required a minimum of two staff members to process large numbers of fish quickly. Three staff were in attendance during peak periods when up to 798 smolts required processing in a short space of time.

Plate 6. The holding tank containing 798 fish.

In all, 6035 smolts were caught in the trap over the period of operation. All juvenile salmonids were anaesthetised, measured for length and sampled if required. Approximately 800 scale samples were collected. Scales from all trapped trout smolts (110) were taken and the remainder taken from salmon. Similarly, genetic samples were collected from all trout smolts and a representative sample from salmon smolts by means of an adipose fin clip. 900 genetic samples in total have been preserved for future analysis. Over 300 fish were weighed. Digital images were taken of predator damage to fish and any other unusual or interesting specimens. Predator damage was recorded with marks attributed to one of the six different categories available.

All fish were released downstream of the trap, initially within 30m but latterly 100m downstream below a shallow riffle (with the exception of those used in recapture trials that were released over 1 km upstream).

Recapture Trial

Three recapture trials were performed. Marked fish were transported upstream and released. Fish were then recorded if they were once again trapped. From the results of these trials, the effectiveness of the trapping was assessed.

The results of the trials and sampling are discussed below.

Results

Catch statistics

The total salmonids catch for the trap was 6025. This includes salmon, trout, hybrids, 2 salmon kelts and two stocked brown trout. Other trapped species included river and brook lamprey, perch, eel, minnow and stone loach.

The salmonid catch is broken down as follows (excluding salmon kelts and hybrids):

Table 1: Breakdown of salmonids captured in the RST

Salmon smolts	Salmon parr	Trout smolts	Trout parr	Adult trout
5719	154	110	30	6

The daily catch of each species is shown below.

Figure 1. Number of Salmon Smolts/Day

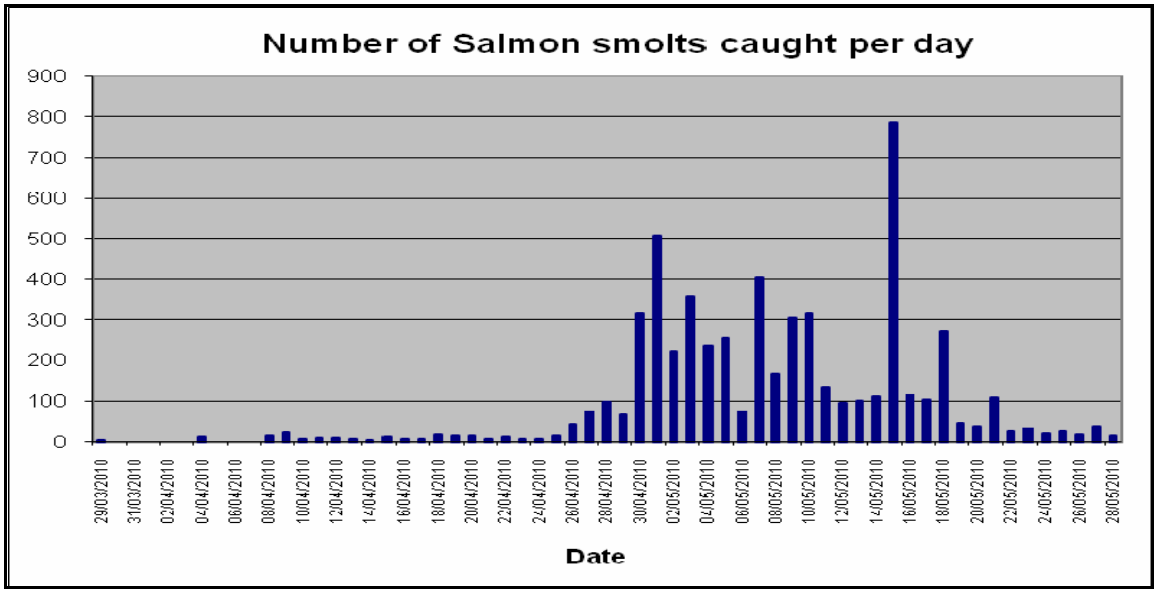


Figure 2. Number of Salmon Parr/Day

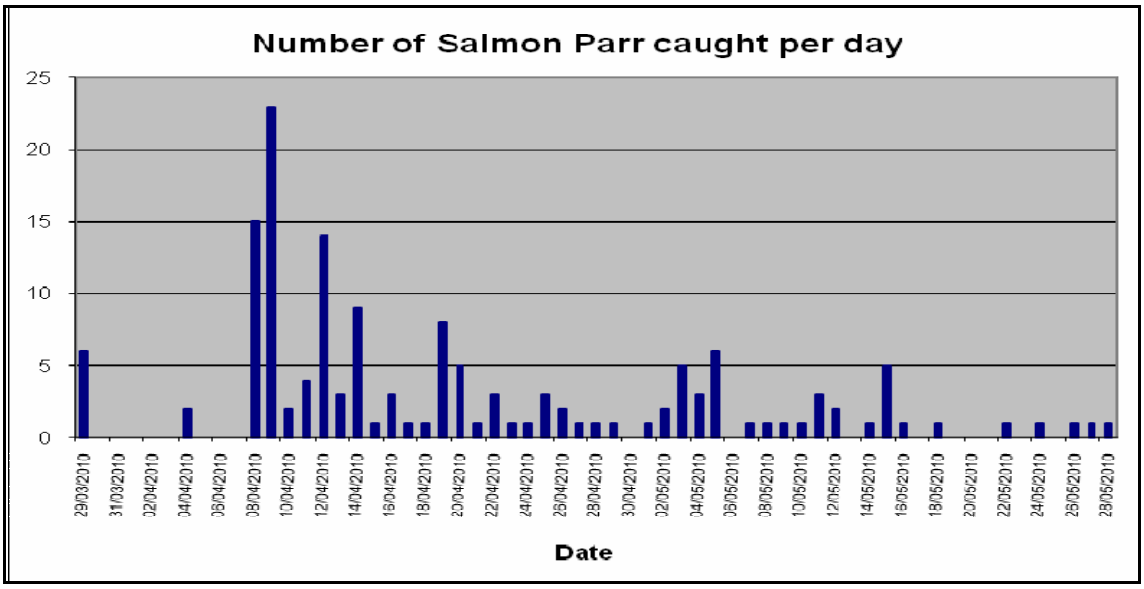


Figure 3. Number of Trout Smolts/Day

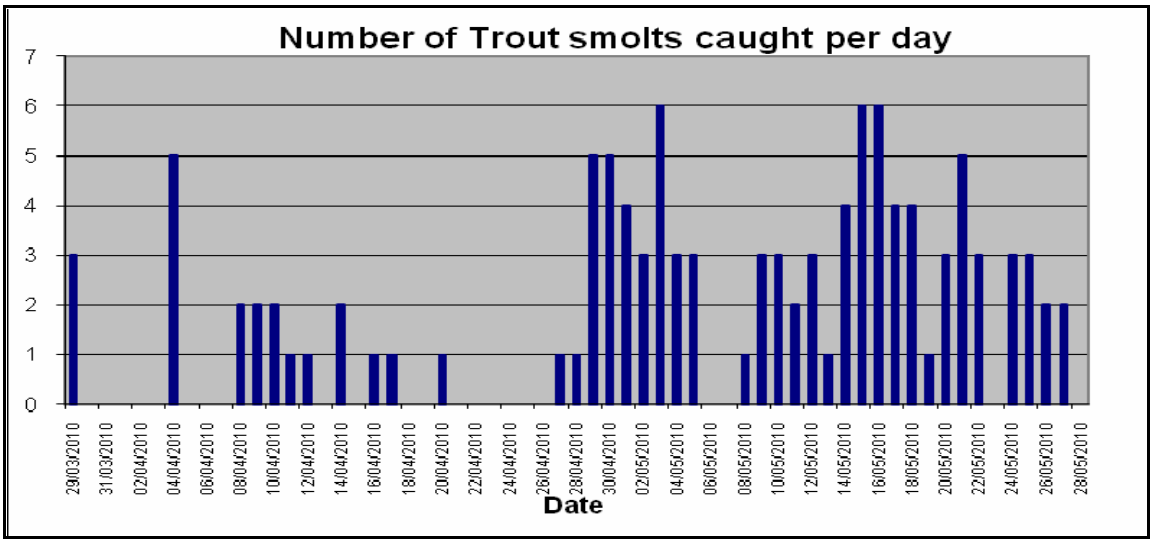
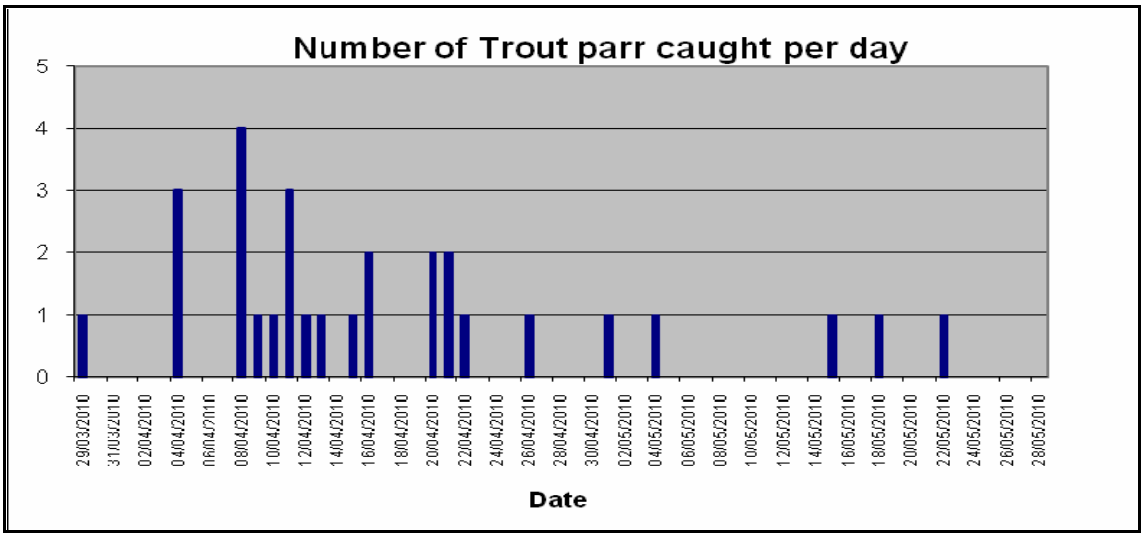


Figure 4. Number of Trout Parr/Day



Salmon smolt size ranged from 101 to 193mm with a mean size of 139.8mm. The mean size of the trout smolts was 192mm, ranging from 119 to 251mm. Some of the sea trout smolts were of a size that could possibly be taken by trout anglers mistaking them for brown trout or sea trout returning from the sea. It may be worth advising anglers on the river that trout up to 250mm (10") could potentially become smolts.

Graphs of the salmon and trout smolt size distribution are shown below.

Figure 5. Size distribution of salmon smolts

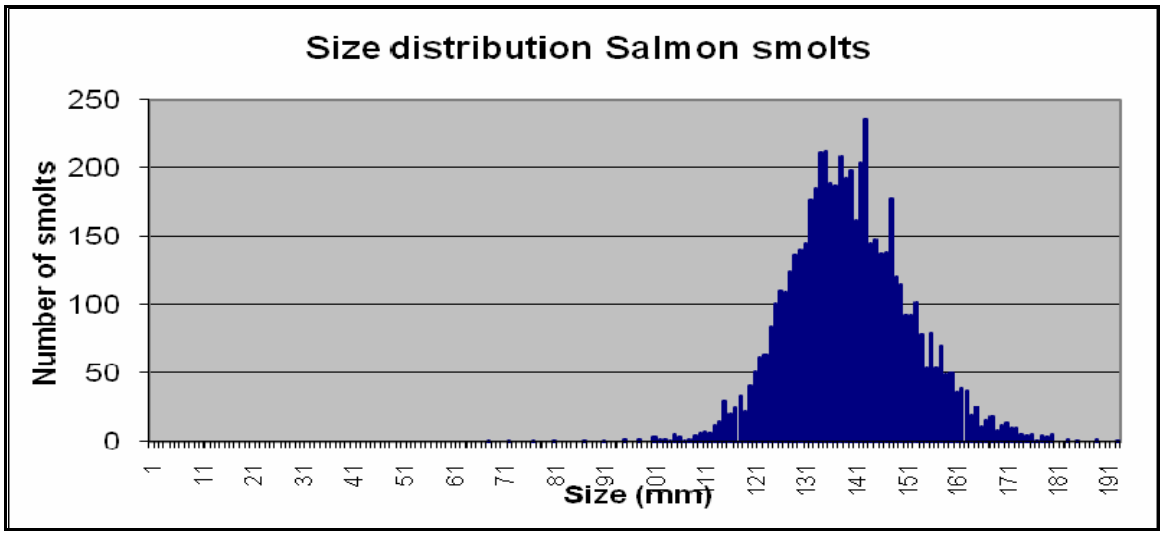
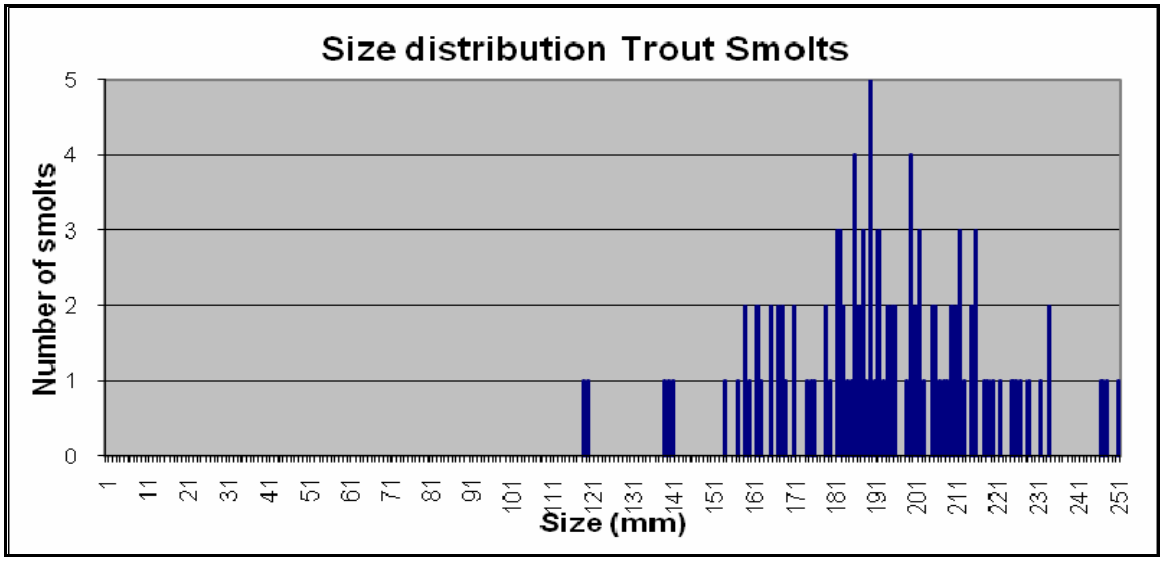
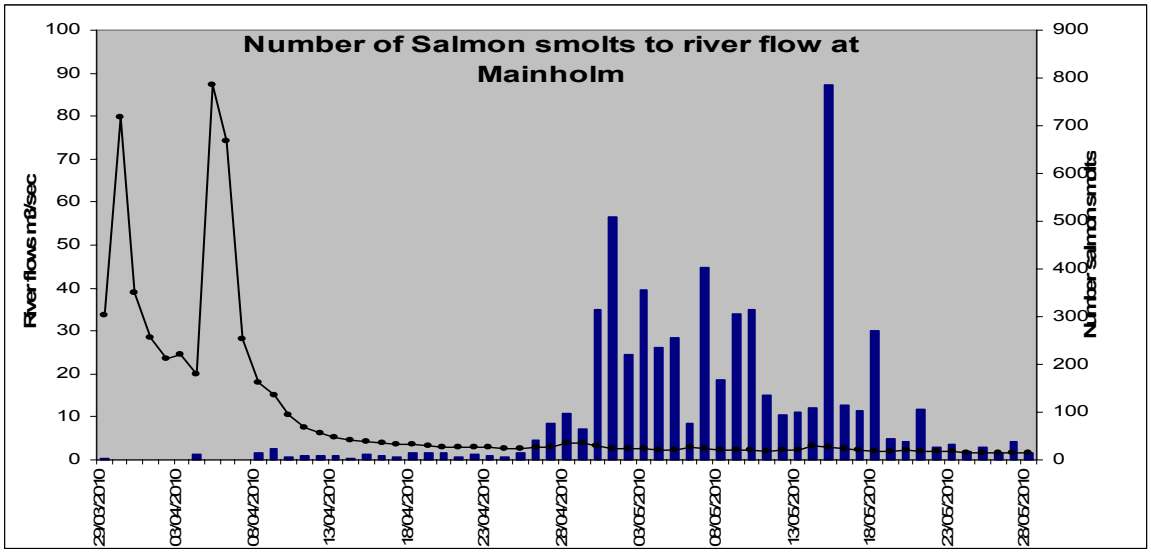


Figure 6. Size distribution of trout smolts



After mid April low water conditions prevailed but the smolt migration was consistent despite reducing water levels. River levels at each of the three gauging stations on the river showed a similar pattern suggesting that rainfall was consistent across the catchment. River flows at the Mainholm SEPA gauging station are shown below alongside catch data.

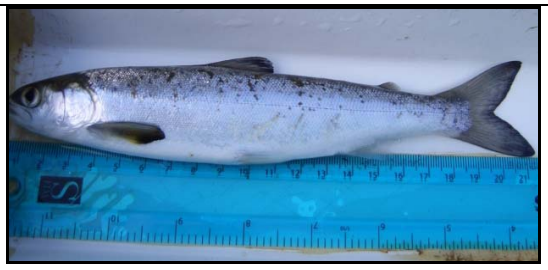
Figure 7. Comparison of river flows to catch results



A large movement of salmon parr was noted, particularly in early April when up to 20 salmon parr/day were caught in the trap.

Two stocked brown trout were captured in the trap. These fish are thought to have originated from a stocking by Mauchline Angling Club approximately 2 miles upstream. Both fish were captured within a few days of the stocking.

Plate 7. A selection of the notable fish from the trap.



Largest salmon smolt at 193mm

251mm sea trout smolt

The only perch caught in the trap

River Lamprey, a first from the Ayr

Salmon Kelt caught during March

Brook Lamprey

Stocked Brown Trout

A brace of pre smolt trout

Predation

Predator damage was recorded using a standard scoring method for different types of damage/marks. Approximately 7% of salmonid smolts were recorded with predator damage. Fish eating birds were responsible for most of the damage to smolts however several fish also appeared to have bite marks from larger fish and others showed damage that may be attributed to angling or other factors. Examples are shown in Plate 8 below. Low water conditions undoubtedly favour predatory birds which at the time of the project were likely to be rearing young. From these results it is not possible to estimate the total number of fish lost to piscivorous birds however with an accurate bird count along the length of the river and data collected elsewhere this is possible and may be worth considering in future.

Of the 7% of smolts showing predator damage, parallel rake marks was the most common mark found. Parallel rake marks are often associated with herons, sawbill ducks and possibly cormorants. Puncture wounds and lacerations are associated with herons and sawbill ducks (both were recorded under puncture wounds, single or multiple). Converging lines is indicative of beak shape and usually associated with herons or sawbill ducks. There is clearly a difficulty in separating the different predatory species using the visible damage.

Some fish may have carried more than one type of mark however the most dominant or common feature was used to calculate percentages. General scale loss and old wounds cannot always be directly attributed to predators however this cannot be ruled out.

Table 2. Occurrence of different predation marks on smolts.

Parallel rake marks	68%	Converging lines	8%
Single puncture wound	3%	Multiple puncture wound	>1%
General scale loss	11%	Old wound	9%
Bite mark	>1%	Other	>1%

Plate 8. Predator damage to smolts

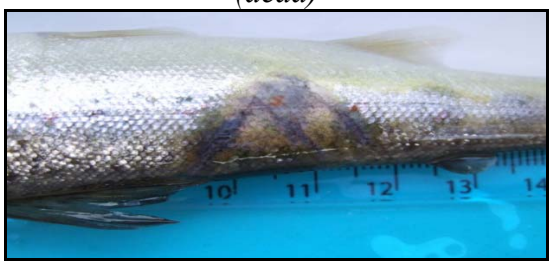
Salmon smolt with bird damage

Laceration from beak

Bite mark from fish

Salmon smolt with worming tackle attached (dead)

Parallel beak marks leading to scale loss



Converging lines from tip of beak

Other Damage

As with any trapping project there is the potential to cause damage to the fish being trapped. RST's are known under certain conditions of operation to cause minor damage to fish either during the intake or time held in the tank. Damage such as scale loss or split fins are most likely. General scale loss was recorded under predator damage at 11%. It is feasible that a small proportion of this damage may have been inflicted as a result of smolts being trapped however there is no way of determining the actual number. As the trap operated almost exclusively in low water conditions, trap damage could reasonably be expected to be minimal.

Of the 6035 salmonids trapped, only one fish was found dead within the trap. It is unlikely that trapping caused this mortality however this cannot be ruled out. One dead adult minnow was found stuck in the drum's mesh and one brook lamprey was also found dead in the tank. The lamprey may have died following spawning or perhaps as a result of damage sustained when netting other fish from the tank.

Quite a few salmonids were recorded with splits to their dorsal or tail. This may be as a result of trapping however this damage is thought to heal rapidly, especially on reaching saltwater.

Trap Efficiency

In order to assess the efficiency of the trap a recapture trial was completed. On the 27th April; 54 salmon smolts and 2 trout smolts were re-released approximately 1.7km upstream of the trap site. Five salmon smolts were recaptured between the 28th to the 30th April, giving a recapture rate of 9%. Four salmon smolts were recaptured on the 3rd May but these are possibly from smolts swimming back upstream from the normal release site. If these are included in the recapture trial results the rate rises to 16%.

A second recapture trial was repeated on the 12th of May. Ninety five salmon smolts were released at the same upstream location as used in the previous trial. Twelve fish were recaptured over 4 days giving a trial result of 13%.

A final recapture trial using 29 fish was performed on the 25th May. These fish were released 1.3km upstream. This time 4 salmon and 1 trout were recaptured over 4 days giving a trial result of 17%. The average of the 3 trials is either 13 or 15.3% depending on which figure is used for the first trial result.

The downstream rate of migration of smolts involved in the recapture trials are shown in the table below. As the river was consistently low throughout the majority of the trial period, recapture trial results are likely to be considerably different to results that could be expected in elevated or spate conditions. The rate of downstream migration is discussed in detail in the discussion section of this report.

Table 3. Rate of recapture results

Trial date	**Mean river flow (Mainholm) m3/sec**	**Migration speed Km/day**		
		Mean	**Max**	**Min**
27th April	2.817	1.14	1.71	0.57
12th May	2.201	1.01	1.71	0.43
25th May	1.616	0.88	1.33	0.44

Age Classification

Following the Atlantic Salmon Scale Reading Guidelines (Shearer, W.M 1992), 791 scale samples were examined to determine age and growth rates of smolts. 10% of the salmon smolts captured were one year old, 88% were two year old and 2%, three year old.

Figure 8. Age distribution of Salmon smolts %.

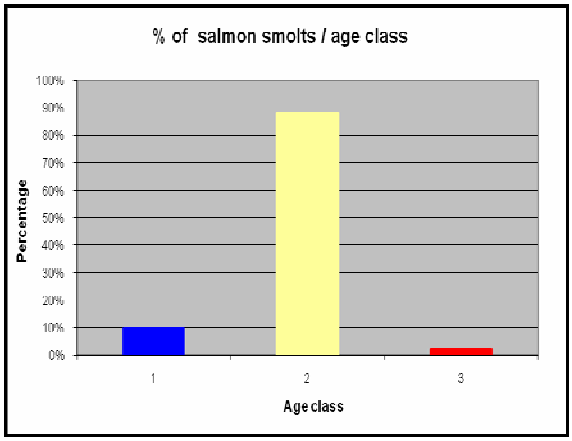


Figure 9. Age distribution of Trout smolts %

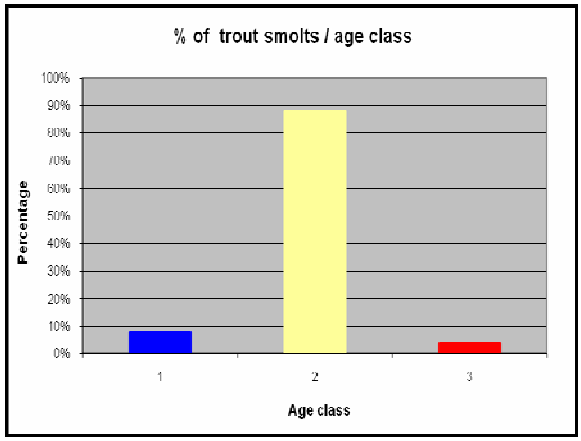
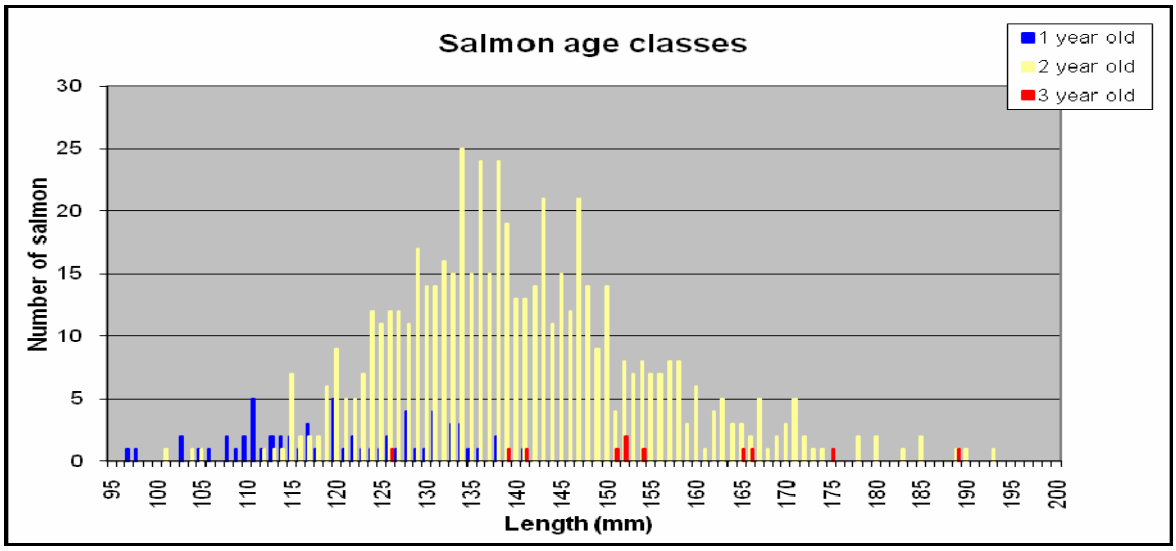
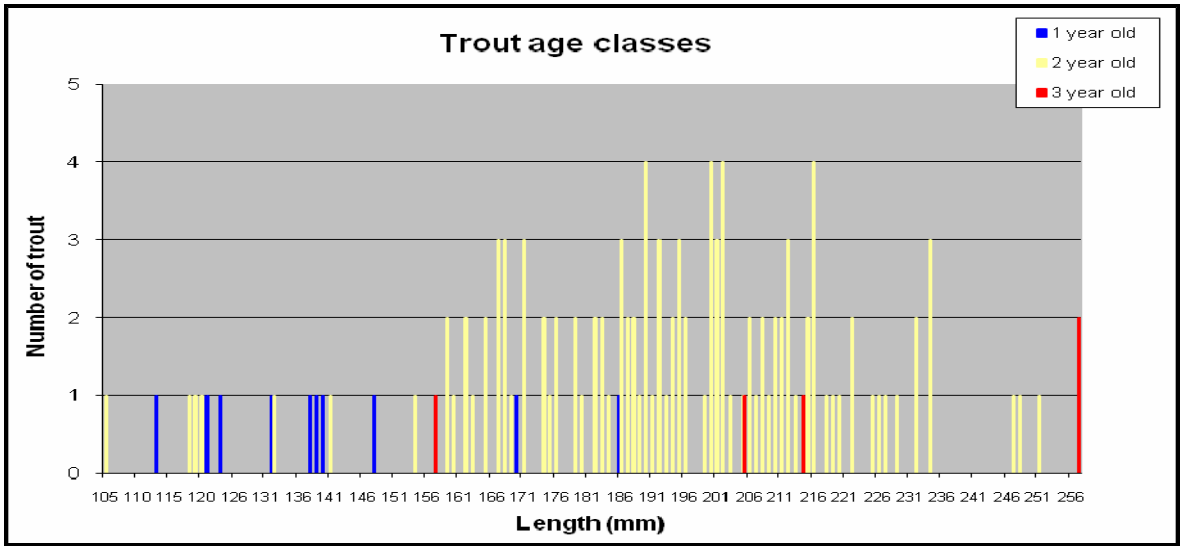


Figure 10. Salmon age class distribution.



The trout results were similar with 8% smolting as one year olds, 88% as two year olds and 4% as three year olds.

Figure 11. Trout age class distribution.



Condition Factor

293 salmon smolts and 10 trout smolts were weighed. From this data, the weight to length ratio and the condition factor of these fish has been calculated.

By plotting the length to weight ratio for both salmon (*figure 12*) and trout (*figure 13*), it is clear that both species closely follow the projected trends with few outlying smolts recorded. When both species are plotted on the same graph (*figure 14*), trout (orange) are noticeably heavier than salmon smolts in relation to their length.

Figure 12. Salmon smolt length to weight ratio

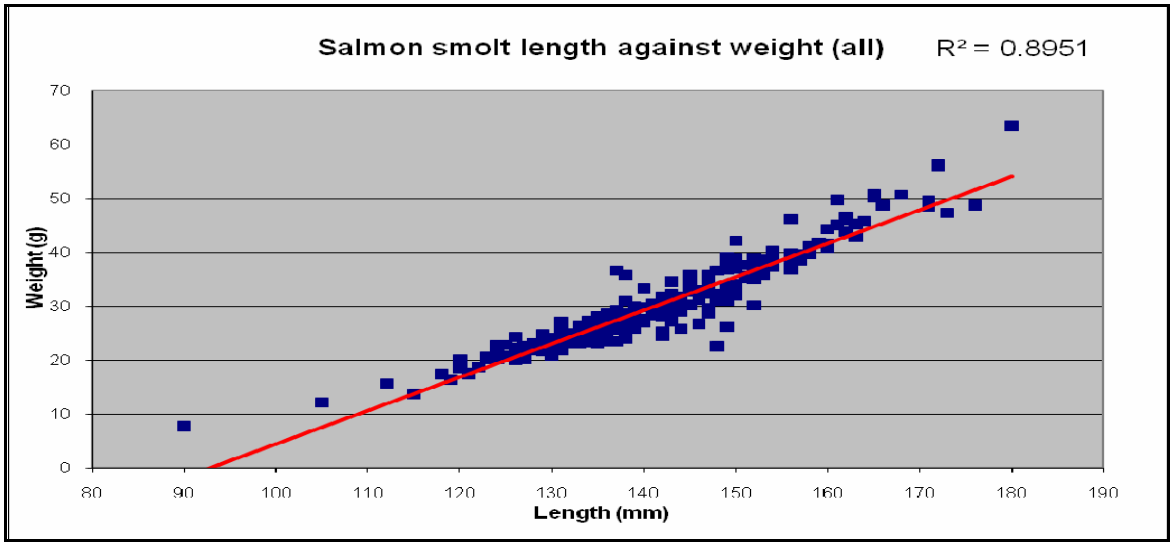


Figure 13. Trout smolt length to weight ratio

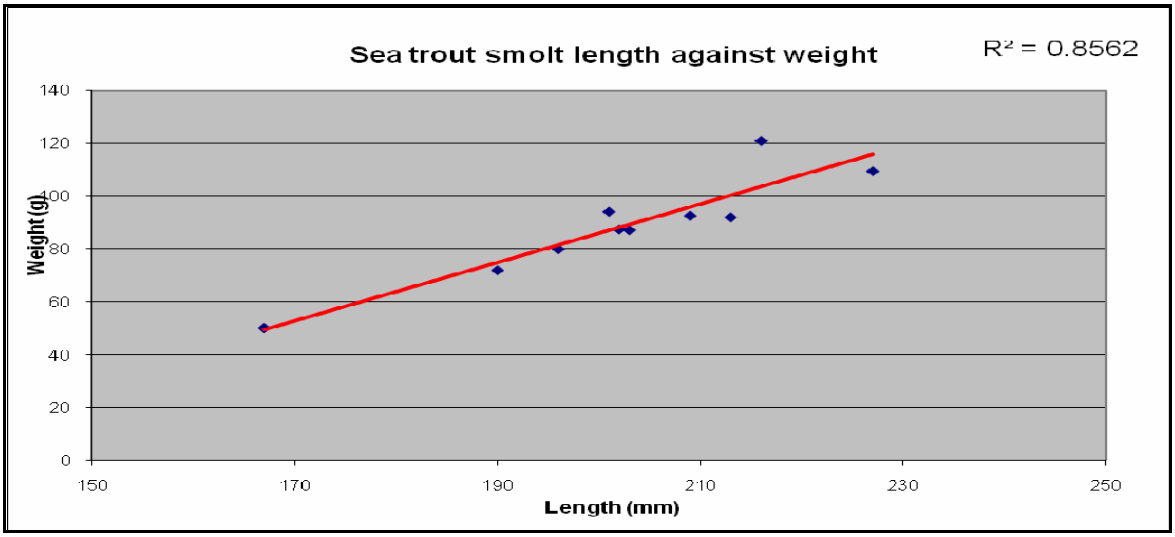
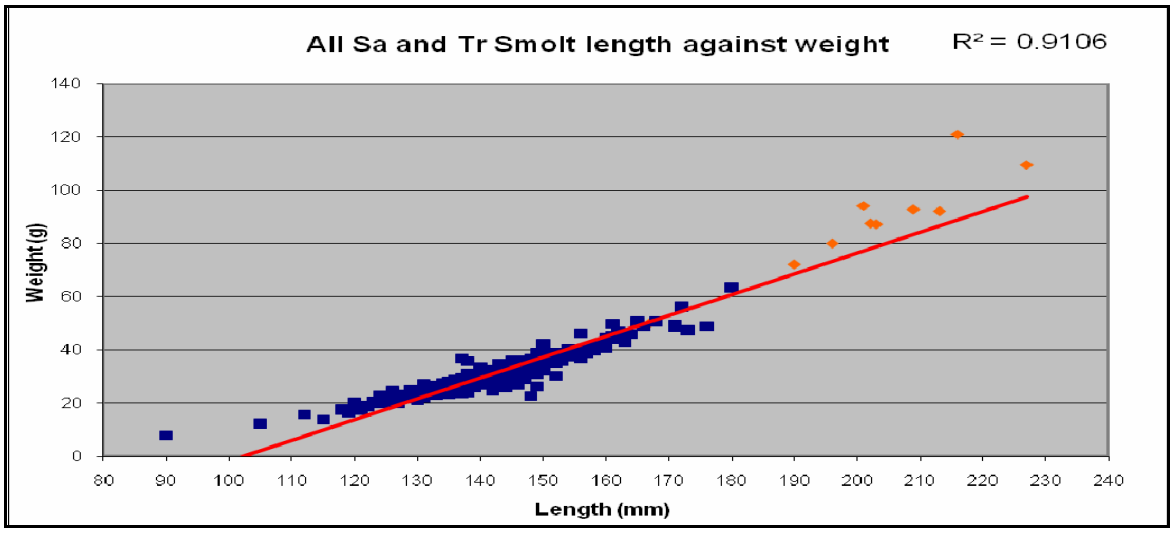


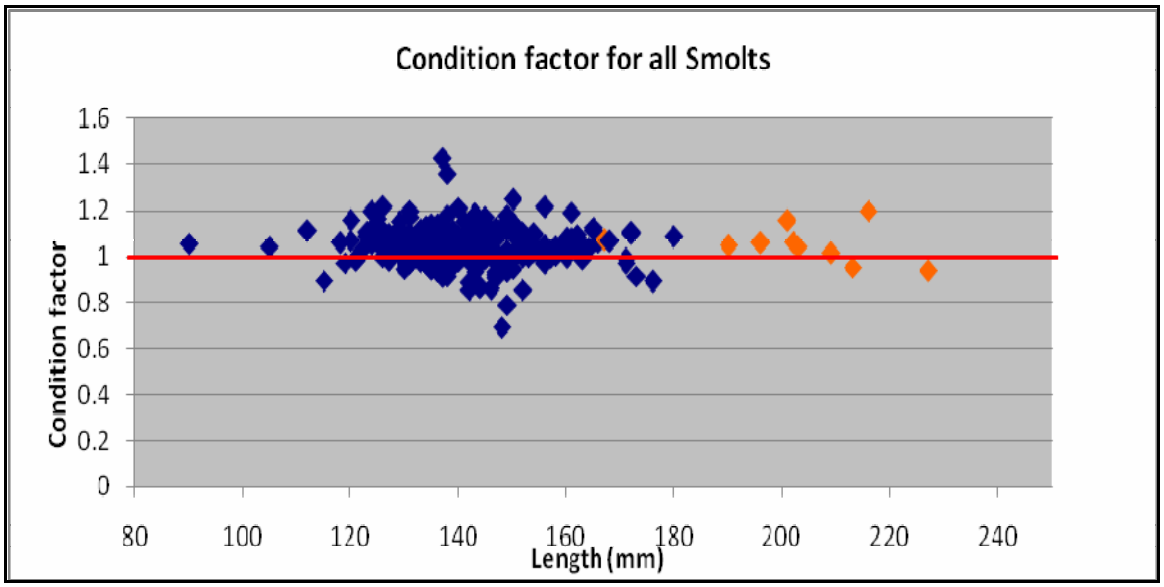
Figure 14. Salmon and trout smolt length to weight ratio



The length to weight ratio can further be explored by calculating the condition factor (CF) of each smolt. This allows individual fish to be compared against an average weight for its length. The formula used was CF = 100 X wt (g)/L (cm)^3. This calculation takes no account of factors such as the fullness of the fishes stomach or gut at the time of weighing which could affect the result however it is a reliable indication of whether a fish may be determined to be in ''good'' or ''poor'' condition. An average fish will have a CF of 1. Those smolts with a CF greater than 1 are above average weight and therefore may be described as in good condition, while those with a CF of less than 1 are below average weight and therefore may be described as in poorer condition.

The results indicate that 25.7% of all smolts were average weight or below with 74.3% average weight or above. Natural variations in body shape may account for much of the variation and there doesn't appear to be any indication that malnourishment should be a concern although this may have implications for sea trout production which will be discussed later.

Figure 15. Salmon and trout condition factor. (>1 being above average weight, <1 being below average weight for the species)



Discussion

The deployment of the RST proved to be a very effective method of sampling salmonid smolts. Smolts were captured in the trap every day that it was operational. Apart from during the first two weeks of the trial water levels were consistently low. Water levels are believed to be an important trigger for smolt migration and the consistent low water during the peak smolt migration period is likely to have had a significant influence on the results.

During April the number of salmon smolts captured was relatively low and stable up until the 26th when there was a significant increase heralding the start of the main smolt run. During early to mid May a high number of smolts were captured peaking on the 15th when almost 800 smolts were recorded. Towards the end of the month the daily catch declined. The old adage says that "the first spate in May takes the smolts away". In the absence of any spates in May 2010 the smolt migration appeared to happen independently of river levels. The extended period of relatively high daily catches in May is a reflection of the relatively low river levels throughout and the absence of any spates.

The pattern for sea trout smolts was slightly different with daily catches more consistent over the entire period of operation, although 72% of the sea trout smolts were captured in May (86% for salmon). The highest daily number recorded was six.

Only 1.9% of all the smolts captured were sea trout smolts. In 2006 the Trust operated a smolt trap in the River Doon where a lower overall number of smolts was recorded, but 4.5% were sea trout. In recent years the rod catch on the River Ayr has been dominated by salmon with a relatively low percentage of sea trout recorded (see Table 4) It is therefore not surprising that low numbers of sea trout were caught in the trap (although this makes no allowance for the sea trout stocking that has taken place). Reported rod catches are often inaccurate and cannot be relied on with confidence. Marine survival of both species cannot be assumed to be similar as they utilise different parts of the marine environment therefore a direct comparison between catch returns and total number of spawning fish cannot be made.

Catch per Unit Effort is different for both species and most sea trout are a result of accidental capture by salmon or brown trout anglers rather than the result of specific sea trout angling.

Table 4: River Ayr rod and line catches 2000 - 2008

	Salmon	Sea Trout	% Sea trout
2000	727	60	7.6
2001	790	11	1.4
2002	630	29	4.4
2003	266	6	2.2
2004	947	29	3.0
2005	712	14	1.9
2006	554	15	2.6
2007	793	16	2.0
2008	746	45	5.7

Further research into marine survival of both species would therefore be helpful as would accurate catch records.

Scale analysis showed that the majority of both sea trout and salmon smolts were two year old at the time of smolting. If the fish were derived from natural spawning then they would be from the run of spawning fish which entered the river in 2007, when the sea trout catch represented 2% of the total. Of course this takes no account of the sea trout stocking that the ADSFB has been implementing.

The mean size of the salmon smolts recorded in the River Ayr was 139.8mm, with the largest salmon smolt being 193mm. In the River Doon smolt trap the mean size of the salmon smolts was 132mm (largest 175mm). Communications with Marine Scotland staff who operate smolt traps on the River North Esk indicate that the mean size of the smolts found in the River Ayr was considerably larger than recorded in the North Esk. The mean size of the migrating smolts will be influenced by a number of factors including food availability, water temperature, smolt age and competition. The Ayr catchment is dominated by sedimentary rocks such as sandstone and limestone and consequently the freshwater environment is relatively productive providing good growth conditions for juvenile salmonids which may explain the overall large size of Ayr smolts.

The mean size of the sea trout smolts recorded in the Doon smolt trap was 149mm, considerably smaller than the 192mm recorded from the Ayr. The large size of the Ayr trout smolts highlights a potential issue regarding angler exploitation of these fish before they have even reached the sea. The largest sea trout smolts were over 10" long and of a size that may be killed by anglers. An important conservation measure for sea trout in the River Ayr would be to educate anglers on the river regarding the existence of such large smolts and to encourage proper catch and release methods.

10% of the salmon smolts captured in the Ayr trap one year olds at the time of migration whereas the Doon smolt trap recorded a higher proportion of one year old salmon smolts (20%) and no three year olds. The two rivers are quite different in character and the Ayr has a large extent of productive and accessible high altitude main stem and tributary sites. It is likely that these upper parts of the catchment are responsible for a large proportion of the Ayr smolt production and that smolts from these areas will generally be two+ years old.

On the Doon the situation was similar with a greater frequency of one year old trout smolts (39%), 55% two year olds and 6% three year old.

During the early period of trap operation, the river was in spate and unfishable for 10 days (not consecutive). On the few days the trap was deployed in falling water levels between spates, low numbers of both trout and salmon smolts were caught however not enough to suggest that large numbers of smolts has passed the trap. The main smolt run commenced around the 21st of April, approximately two weeks after the last spate.

River flows throughout the smolt migration period were generally low with only a few small rises up to 4" occurring. This would have a major bearing on the duration of the smolt migration and the speed of downstream migration. The results from the recapture trials conducted found that the mean downstream migration of the smolts was in the order of

1km/day. The smolt trap was located 14.5km from Ayr and if the migration speeds recorded during the trials were typical of the migration speed between the trap and the sea, then the time taken for smolts to travel from the middle and upper river would be measured in weeks rather than days. This slow migration partly explains the abundance of smolts observed in the lower river during May. Had there been a spate during May then the smolt migration period would have been compressed with a greater exodus during high water conditions.

A significant number of salmon parr were captured in the trap, mainly in the early deployment period with 70% in April. This downstream movement of parr provides an explanation for higher densities of salmon parr to fry often found in the lower Ayr when electrofishing. Evidence from redd counts and electrofishing surveys suggests that egg survival is poor in much of the lower river, possibly due to siltation and low hyporheic oxygen levels. The high densities of salmon parr often found maybe due to downstream migrants settling in what is often good parr habitat.

The predation monitoring found high levels of what was considered to be bird damage. The extended low water conditions during peak migration meant that the smolts were particularly exposed to predation. Salmon and trout parr are known to be territorial during their juvenile stages in the river. Their familiarity with their immediate surroundings may infer a degree of protection from bird predation. However during the smolt migration they tend to form shoals and migrate downstream through unfamiliar waters. Predators such as herons take advantage of this seasonal availability and can take a significant proportion of the smolts. 7% of the smolts captured showed sign of encounters with predators, typically beak marks. These fish are of course the ones that got away. It is impossible to quantify the actual number of smolts lost to predators using a smolt trap but it can be assumed to be significant.

As well as ongoing predation losses within the river from birds such as herons, sawbill ducks and cormorant, estuaries are known to be bottlenecks where the smolts can be subject to high predation levels from diving birds. Cormorants were observed daily in the tidal pool below the Nethermills Weir feeding on smolts. In a dry year such as 2010 predator losses are likely to be very significant resulting in an irreplaceable loss from the potential return of adults.

Interestingly, on three occasions the trap was monitored from shortly before dusk until sometime after total darkness. This was an informal observation to identify when smolts actually migrate. Commonly, anglers talk about seeing smolts descending rivers at dusk. During these observations, no smolts were found in the trap before dusk. On each occasions, between 55 minutes - 1 hour and 10 minutes passed before the first smolt was observed entering the holding tank. Thereafter, smolts steadily entered the trap. No attempt was made to monitor when smolts stopped entering the trap or until dawn.

As very few smolts were caught during daylight hours (evening checks rarely found smolts in the tank) and none appeared to enter (during the observations) until complete darkness, it is possible that smolts could see the trap and avoided being caught. Alternatively, this may indicate that in low water conditions, in order to evade predators, smolts mainly migrate downstream during total darkness. Further overnight observations would be worthwhile in future trapping exercises and in a variety of flow conditions.

One of the main drivers for the deployment of the smolt trap in the River Ayr was to try and assess the production of sea trout smolts within the river. The Ayr DFSB has undertaking a sea trout enhancement programme since 2005 with the annual purchase of approximately 200,000 sea trout ova from Loch Carron in the West Highlands. The resulting alevins have been stocked as unfed fry in a number of upper tributaries each year. Genetic analysis of fish has advanced rapidly in recent years and it should be possible to determine with some degree of confidence the origin of any sea trout sampled. To that end genetic samples were collected from all the sea trout captured. These samples are now in storage at the Marine Scotland Laboratory in Pitlochry, where they will kept until they can be analysed. The sea trout stocking programme undertaken by the DFSB began in 2005. As most of the sea trout captured were two year old they would have been from eggs produced in the winter of 2007/8. The original source of the sea trout used in the restocking programme was from stock derived from sea trout taken from the Ewe catchment. It is likely that they would have a genetic make up quite different to native fish from the River Ayr and it should be possible to determine the parentage from genetic analysis.

In order to try and assess whether the costs incurred in the Ayr sea trout enhancement are resulting in increased production of sea trout smolts in the river it should be considered a priority to complete the genetic analysis of the sea trout samples. The costs of this analysis are likely to be around £3000.

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