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Report To: NRA Southern
IFE Report Ref. No: RL/T11063g7

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Report Date: March 1996
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PISCIVOROUS PREDATION ON STOCKED SALMON PARR IN A CHALK STREAM

Executive summary

Six sites on the River Anton were surveyed three days after and one month after the introduction of PIT tagged salmon parr to one of the sites. Six sites on the River Test were surveyed four days after the introduction of PIT tagged salmon parr to one of the sites.

The efficiency of fish capture in the River Test sites was very low due to the size of the river and although the data is presented its quality precludes it from meaningful discussion. Thus most of the report concentrates on the survey of the River Anton.

Three days after the stocking of the salmon parr a total of 11 (3%) were captured in the River Anton within 350 m in a downstream direction of the point of stocking. None were captured in a further 200 m downstream, or 150 m upstream. A similar number of salmon parr (3%) were detected inside piscivores, mainly brown trout. One month after the initial stocking 4 (1%) of the stocked salmon were recaptured, within 550 m in a downstream direction from the point of stocking, and 2 (0.5%) were detected inside piscivores.

Brown trout as small as 27.9 cm fork length had consumed salmon parr, although most salmon were consumed by trout in the size range 32 - 35 cm.

Within the sites sampled, on the River Anton, there was some downstream movement of salmon parr between the first survey three days after the stocking and the survey repeated one month later.

It is recommended that stock enhancement of salmon in the River Test is evaluated experimentally as discussed in the main body of the report.

Introduction

Currently, there is a stock enhancement programme for salmon in the River Test catchment. Salmon parr are reared from the egg stage and then released as parr in late autumn prior to smolting the following spring. The parr are often PIT tagged and there is a smolt trap which captures a small number of these fish on their outward migration to the sea. However, nothing is known of the distribution or fate of the stocked fish during the winter months between release and recapture.

The objective of this survey was to make an initial study into the fate of salmon parr stocked at two sites in the River Test catchment, with particular respect to piscivory by other fish species, as well as dispersal within the local area of the release point.

Methods

Study sites

Six sites on each of the River Anton and the River Test were selected for study (Fig. 1a & b). In each river three sites were termed the stocked sites. In one of these three sites, 363 salmon parr were introduced at a single point on 15 December 1995. The other three sites were located a short distance downstream from the stocked sites and were termed the unstocked sites. Each site was 100 m in length. The salmon parr were stocked in the centre of site 2 on the River Anton (Fig 1a) and at the top of site 3 on the River Test (Fig 1b).

Survey design

Originally, it was intended to survey each site within a week of the original stocking and then every 30 days until March. However, conditions of high water in the River Test made those six sites very difficult to survey effectively and only one survey was completed. On the River Anton very few salmon parr were found, making continuation of the surveys less important and only two surveys were completed on these sites (Table 1).

Table 1.The dates of stocking with salmon parr and the dates of subsequent surveys.

		Stocking date	1st survey	2nd survey
River Anton	Stocked sites	15/12/95	18/12/95	08/01/95
	Unstocked		19/12/95	12/01/95

	sites			
River Test	All sites	15/12/95	19/12/95	n/a

Figure 1a. Map of River Anton and the six sites surveyed.

Figure 1b. Map of the River Test and the six sites surveyed.

Electric fishing

Electric fishing was carried out by a five person team, using twin anodes attached to a 2.5 KVa generator pulled along in a small boat. One person was responsible for pulling the boat and on each side of the boat two persons operated an anode and a net. On the first survey in December each site was fished only once by moving at a steady walking pace from the bottom of the site in an upstream direction. On the second survey in January, completed on the River Anton only, a triple shock was completed on each site in order to estimate density of fish species by catch-depletion. The estimated efficiency of capture derived from the triple shock was used to calibrate the single fishing in December and estimate the density of each fish species on that occasion. This was not possible for salmon and pike for which efficiencies could not be calculated.

Salmon parr

All salmon parr were measured, weighed, inspected for the presence of PIT tags with a PIT tag reader and checked for the absence of their adipose fin (indicative of the presence of a micro tag). Any salmon without a PIT tag or microtag were assumed to be wild and were marked with a blue panjet mark on their belly. All fish were returned alive to the site from which they came.

Trout, grayling and pike

All fish captured were measured and a sample was weighed and had scales removed for age analysis. Each fish was inspected for the presence of PIT tags in the stomach with use of a PIT tag reader. Fish were inspected from every angle to ensure that if there was more than one tag they would all be registered. All trout and grayling captured in December were marked with a panjet mark on the belly and returned alive to the site from which they were captured. Pike were marked with a fin clip because pan jetting is not an effective method for marking this species. During the January survey all fish were noted, from their marks, as being captured in December or not.

Analysis of environmental measurements

On each occasion that a site was fished an environment appraisal form was completed at the same time. This form was based on the HABSCORE form, but differed in that only five transects were used for each site. The data on the forms were then used to generate a total of 25 environmental variables describing depth, substrate, flow and cover (Appendix 1, Table A.1).

Single regressionary techniques were used with salmon parr density as the dependent variable and the environmental measures, together with estimated densities of other fish species, as the independent variables. Where the same site had been fished on more than one occasion this was treated as two sites in

the analysis. The objective of this technique was to explain as great a proportion of the variation in between-site fish density as was possible with the data available.

This procedure was completed on the data obtained from both the River Anton and the River Test. However, it was felt that the efficiency of fish capture on the Test was very low because of the water conditions at this site and therefore the regressionary techniques were repeated for the River Anton only.

Stepwise regressionary techniques were not used because of the low numbers of dependent variables, that is 18 with the River Anton and Test combined and 12 with the River Anton alone, in comparison to the high number of independent variables (28). In such cases regressionary statistical methods can capitalise on chance patterns in the data resulting in spurious explanations of variance.

Results

Most of the population statistics, including size frequency distributions and the results from the scale reading, collected on the trout, grayling and pike captured are included in the Appendices to this report.

Very few fish were captured in all the River Test sites. This was undoubtedly due to the water conditions reducing the efficiency of the electric fishing to an unacceptable level. Therefore, the data collected from this site, although quoted and presented in the text, has not been subjected to any statistical analysis.

Salmon parr

In December a total of 11 salmon parr were captured in the River Anton and 3 in the River Test, all of which were PIT tagged (Table 2).

Table 2.Total numbers of PIT tagged, adipose fin clipped and wild salmon captured in six sites in each of the River Anton and River Test.

Numbers of Wild, PIT Tagged and Adipose Clipped Salmon.			
	Wild	PIT Tagged	Adipose Clipped
R.Anton December	0	11	0
R.Anton January	2	4	2

R.Test	December	0	3	0

Figure 2. Density of PIT tagged salmon parr captured at six sites on the River

Anton (a) in December and January and at six sites on the River Test (b) in December.

Table 3.Density of fish species captured in six sites on each of the River Anton and River Test.

Fish Densities (no. ha^{-1})								
	Trout		Salmon		Grayling		Pike	
	Dec	Jan	Dec	Jan	Dec	Jan	Dec	Jan
Anton Stocked								
Site 1	214.6	354.5	65.3	9.3	139.9	261.2	0	9.3
Site 2	441.7	335.7	26.5	17.7	203.2	229.7	8.8	8.8
Site 3	138.9	234.4	0	0	156.3	303.8	17.4	17.4
Anton Unstocked								
Site 1	121.6	89.1	0	16.2	218.8	470.0	0	0
Site 2	256.9	342.5	0	0	453.8	411.0	0	0
Site 3	392.2	423.5	7.8	23.5	376.5	447.1	23.5	0
Test Stocked								
Site 1	6.0		0		42.2		0	
Site 2	0		6.2		6.2		0	
Site 3	13.0		0		13.0		0	
Test Unstocked								
Site 1	0		10.9		5.5		0	
Site 2	15.0		0		7.5		0	
Site 3	6.5		0		0		0	

Figure 3a. Density of trout, salmon parr, grayling and pike captured at six

sites in December and January on the River Anton.

Figure 3b. Density of trout, salmon parr, grayling and pike captured at six

sites in December on the River Test.

By January this number had reduced to 8 salmon parr in the River Anton of which 4 were PIT tagged (Table 2). Between the two survey times there was a distinct shift of the fish in a downstream direction. In the first sampling between three and four days after the stocking, all the fish were captured within 350 m in a downstream direction of the point of stocking. No PIT tagged salmon were captured in the 200 m further downstream. However, in January some PIT tagged salmon were captured in the site furthest downstream from the point of stocking. No PIT tagged salmon were captured upstream of the point of sampling (Fig 2).

All of the salmon parr captured had a healthy appearance with the exception of one which looked thin and dark coloured. This fish had a relative condition of 0.86, where relative condition is equal to its measured weight divided by its expected weight as derived from the length weight relationship calculated for all salmon captured (see Appendix B, Table B.1).

Piscivorous predation.

In December a total of 12 PIT tags were found inside other fish captured in all the River Anton sites and 3 in fish captured in the River Test. By January this number had reduced to 2 in the River Anton (Table 4; Appendix C, Table C.1). Most of the PIT tagged salmon eaten had been consumed by trout. This was because the other piscivores, pike, were low in number. No PIT tags were found in any of the grayling.

There were no significant differences between the sizes or densities of piscivores captured in stocked and unstocked sites on any occasion.

In the River Anton sites immediately below the point of stocking as many as 27% of the trout captured had PIT tags inside them in December (Table 5). Comparative figures for the River Test sites were as high as 100%, but this is based on the capture of only one fish. In January the proportion of piscivores with PIT tags inside them was far less and the distribution of piscivores with PIT tags did not coincide with the presence of live PIT tagged salmon. For example, a trout was caught upstream of the stocking point with a PIT tag inside it, but no PIT tagged salmon were ever caught above the point of stocking.

Table 4.Numbers of PIT tagged salmon parr found inside trout and pike captured in the River Anton and River Test.

River	Month	Trout	Pike
R. Anton	December	11	1
R. Anton	January	1	1

R. Test	December	3	0

The smallest trout found to have consumed a PIT tagged salmon parr was 27.9 cm (Fig 4, Appendix C, Table C.2). However the majority of PIT tagged salmon were consumed by fish sized between 32 and 35 cm (Fig. 4).

Figure 4. The cumulative percentage of PIT tagged salmon parr consumed by

trout plotted against trout size at six sites on each of the River Anton and River Test

Table 5.Percentage of trout and pike captured that contained PIT tagged salmon parr in six sites on each of the River Anton and River Test.

Percentage of Trout and Pike containing PIT tags		R.Anton				R.Test	
		Trout		Pike		Trout	Pike
		Dec	Jan	Dec	Jan	Dec	Jan
stocked	Site 1	27.8	0.0	n/a	100.0	100.0	n/a
	Site 2	6.7	0.0	100.0	0.0	n/a	n/a
	Site 3	0.0	3.8	0.0	0.0	50.0	n/a
unstocked	Site 1	0.0	0.0	n/a	n/a	0.0	n/a
	Site 2	0.0	0.0	n/a	n/a	n/a	n/a
	Site 3	7.0	0.0	0.0	0.0	0.0	n/a

Between 11.5 and 36.8 % of those trout captured in December in the River Anton sites were recaptured in January (Table 6).

Table 6.Proportion of trout and pike captured in each of six sites on the River Anton in January that had panjet marks or fin-clips from a previous capture in December.

	Stocked			Unstocked		
	Site 1	Site 2	Site 3	Site 1	Site 2	Site 3
% Trout Panjetted	26.3	36.8	11.5	14.3	30.0	16.7
% Pike Fin-clipped	0.0	0.0	0.0	n/a	n/a	0.0

Analysis of environmental measurements

Three out of 28 independent variables showed a significant relationship ($p<0.05$) with salmon parr density, both with and without the sites from the River Test (Table 7 & 8).

Table 7.List of environmental variables which explained a significant amount of the variation in, between site, salmon parr density for the River Anton and River Test. Data show regression statistics of the form y = a + bx; where y = density of salmon parr and x = environmental variable.

Predictor	a (t value)	b (t value)	Variance explained (%)	Probability
Substrate - Area of cobbles	4.04 (1.2)	63.1 (3.65)	42.1	p = 0.002
Cover - Area of outstream vegetation	- 3.06 (- 0.63)	39.1 (3.44)	38.9	p = 0.003
Cover - Area of deep water	6.02 (1.55)	13.0 (2.31)	20.4	p = 0.034

Table 8.List of environmental variables which explained a significant amount of the variation in, between site, salmon parr density for the River Anton only. Data show regression statistics of the form y = a + bx; where y = density of salmon parr and x = environmental variable.

Predictor	a (t value)	b (t value)	Variance explained (%)	Probability
Cover - Area of outstream vegetation	- 12.4 (- 1.91)	62.6 (4.61)	64.8	p = 0.0001
Substrate - Area of cobbles	3.99 (0.71)	63.2 (2.71)	36.5	p = 0.022
Average depth	- 76.1 (- 1.99)	1.85 (2.35)	29.2	p = 0.04

Discussion

Dispersal

Most of the salmon parr recaptured in December were found in the sites closest, in a downstream direction, to the point of stocking and no fish were found further than 300 m from the point of stocking in the River Anton. In the River Test, however, although the capture efficiency was low some salmon parr were found as far as 700 m downstream from the point of stocking. By January, in the River Anton the parr had shifted further downstream with fish being recaptured in the site furthest downstream, 550 m from the point of stocking.

Dispersal outside the local area surveyed could not be quantified.

Piscivory

There are examples of predation amongst salmonids reported in the scientific literature, although where this has occurred, there has been little attempt to quantify the impacts at the population level. Fausch & White (1981) reported brown trout predating on brook trout and partially blamed this for the decline of brook trout populations. Alexander (1979) found that brown trout were the most important predators of brook trout and brown trout juveniles. Rainbow trout have been found predating on downstream migrating fry of Sockeye salmon (Ginetz & Larkin, 1976; Swartzman & Beauchamp, 1990) and juvenile chum salmon (Fresh & Schroder, 1987).

Placing a large number of farmed salmon parr in one place inhabited by a high density of large piscivorous brown trout does create the perfect conditions for piscivory. Thus it is not surprising to find that the brown trout contained PIT tags, that is, that they had consumed some of the salmon parr.

As a minimum estimate 3% of the salmon parr stocked were found alive in the sites surveyed three days after stocking in the River Anton. Survival may have been higher because the electric fishing technique of performing one shock will underestimate the number of fish and nothing is known of the distribution of these fish outside the area surveyed. About an equal percentage of the salmon parr stocked were found inside the stomachs of piscivores. It is not possible to calculate the numbers of salmon parr consumed from this information since we would expect the numbers of parr consumed to have been far greater within a few hours of the stocking. Evacuation rates estimated from Elliott (1991) suggest that, at the temperatures experienced, each parr consumed would pass through the gut of a trout in approximately 30 hours. This assumes that the PIT tags are not held back for a longer period. Thus any fish consumed in the first two days after stocking cannot be accounted for.

In January the minimum estimate of the number of stocked salmon parr

remaining within the surveyed sections was 1%, with another 0.5% being found in the stomachs of piscivores. Again total survival may have been higher because nothing is known about the distribution of these fish outside the area surveyed.

The problem comes in interpreting the significance of these observations. Mortality rates for stocked farmed salmon parr are normally high, and many of the fish taken by predators may have been sick, weak and close to death in any case. Indeed at least one of the salmon parr captured appeared to be suffering from starvation. It is possible that the number of survivors to later stages is unaffected by the presence of predators. Thus it is difficult to conclude whether predation by the brown trout, or any other piscivore, would have any impact on the final smolt production or more importantly the number of adult salmon returning to spawn.

Analysis of environmental measurements

Although, some of the environmental measurements showed significant relationships with the density of salmon parr, this data has to be treated with caution for the following reasons:-

(a)Some of the dependent variables are derived from repeat fishings of the same sites.
(b)The density of salmon parr will be directly related to whether they were stocked into a particular site or not. For example, no salmon parr were found in the site above the point of stocking on the River Anton. This will have the effect of masking any impacts of the environment.
(c)As in (b) above any relationship with habitat variables may simply reflect the habitat characteristics perceived as favourable by the individual involved in the stocking.
(d)The low number of dependent variables compared to the number of independent variables increases the chance of a significant relationship occurring.

For these reasons it is probable that no importance can be attached to the significant relationships between salmon density and environmental variable found in this study.

Future work

Stock enhancement, as a management strategy, on the River Test needs to be evaluated properly. This will involve an initial step of setting the criteria by which it is to be evaluated. In the case of migrating salmon it needs to be the number of returning spawning adults, not just the number of smolts produced, because the stocking strategy could affect both river and sea survival.

There is some advice available on stocking rivers with salmon (e.g. Egglishaw *et al.*, 1984,), which, for instance advises spreading parr out thinly over a large area of stream bed and not placing them all at one point. At present, however, it is not known whether enhancement is better served by stocking at different times of the year, with different sizes of fish, at different geographical locations or at different times of day. Even if such advice were available in a general sense, it is probable that different river catchments will have an optimum stocking strategy unique from other catchments.

To elucidate the most efficient method for enhancing salmon in the River Test catchment it would be necessary to perform a catchment wide experiment testing the effectiveness of stocking at different life stages, in different geographical locations and at different times of day. If stock enhancement is to be a major part of the management of salmon then investment in this experiment, would ensure much more efficient use of future stock enhancement resources.

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APPENDIX A.

ENVIRONMENTAL MEASUREMENTS

Table A.1.A list of the environmental variables measured at each site on the River Anton and River Test.

List of environmental variables measured

Trout density
Grayling density
Pike density
Conductivity
Temperature
Average width
Average depth
Average velocity
Substrate - Area of bedrock *
Substrate - Area of boulders *
Substrate - Area of cobbles *
Substrate - Area of gravel *
Substrate - Area of sand, silt and clay *
Flow - Area of cascade *
Flow - Area of riffle *
Flow - Area of deep glide (> 30 cm depth) *
Flow - Area of shallow glide (< 30 cm depth) *
Flow - Area of deep pool (> 30 cm depth) *
Flow - Area of shallow pool (< 30 cm depth) *
Cover - Area of boulders *
Cover - Area of tree roots *
Cover - Area of branches *
Cover - Area of undercut banks *
Cover - Area of instream vegetation *
Cover - Area of outstream vegetation *
Cover - Area of deep water (> 10% of width) *
Total area of cover *
Distance to centre of site from point of stocking

* These environmental variables were assigned to categories.

Table A2.Values for environmental measurements taken at six sites on the River Anton in December.

Site		Environmental variables										
		Conductivity (μs)	Temperature (°C)	Average Width (m)	Average Depth (cm)	Bed Gradient (cm/100m)	Average Velocity m s^{-1}	Total Cover *	Substratum particle size **	Area of Cobbles ***	Area of out-stream vegetation ****	Area of deep water *****
Stocked	Site 3	554	9.4	11.52	45	36	0.461	4.8	silt	0	0.3	1.5
	Site 2	592	9.1	11.32	49	45	0.480	4.3	gravel	0.25	0.8	0
	Site 1	566	9.0	10.72	54	15	0.381	3.75	gravel	0.5	1.0	1.75
Unstocked	Site 3	603	8.1	12.34	46	84	0.477	2.8	gravel	0	0.3	0
	Site 2	566	7.9	11.68	37	3	0.511	1.7	silt	0	0.2	0
	Site 1	622	7.5	12.75	40	20	0.382	3.2	silt	0	0.2	0

* This is the sum of categorical scores for each of six types of cover; large substratum particles, tree roots, branches, in-stream vegetation, out-stream vegetation and deep water.

** This represents the dominant substratum particle size in each site.

*** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%.

**** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%

***** This is the mean of categorical values assigned to each transect where 0=0%, 1=<1%, 2=1-10%, 3=11-20%, 4=>20% of water with depth greater than 10% of width

Table A3.Values for environmental measurements taken at six sites on the River Test in December.

Site		Environmental variables										
		Conductivity (μs)	Temperature (°C)	Average Width (m)	Average Depth (cm)	Bed Gradient (cm/100m)	Average Velocity m s^{-1}	Total Cover *	Substratum particle size **	Area of Cobbles ***	Area of out-stream vegetation ****	Area of deep water *****
Stocked	Site 3	578	8.8	15.37	67	23	0.573	0.2	gravel	0	0.2	0
	Site 2	648	8.9	16.11	51	44	0.845	0	gravel	0	0	0
	Site 1	612	8.8	16.58	62	9	0.719	0	gravel	0	0	0
Unstocked	Site 3	588	8.9	18.35	73	47	0.449	1.95	gravel	0	0.7	0
	Site 2	596	8.8	13.34	89	36	0.310	4.3	silt	0	0.3	0
	Site 1	615	8.9	15.35	86	4	0.265	4	silt	0	0	0

* This is the sum of categorical scores for each of six types of cover; large substratum particles, tree roots, branches, in-stream vegetation, out-stream vegetation and deep water.

** This represents the dominant substratum particle size in each site.

*** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%.

**** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%

***** This is the mean of categorical values assigned to each transect where 0=0%, 1=<1%, 2=1-10%, 3=11-20%, 4=>20% of water with depth greater than 10% of width

Table A4.Values for environmental measurements taken at six sites on the River Anton in January.

Site		Environmental variables										
		Conductivity (µs)	Temperature (ºC)	Average Width (m)	Average Depth (cm)	Bed Gradient (cm/100m)	Average Velocity m s^{-1}	Total Cover *	Substratum particle size **	Area of Cobbles ***	Area of out-stream vegetation ****	Area of deep water *****
Stocked	Site 3	645	9.7	11.18	46	36	0.607	2.5	silt	0	0.3	1.5
	Site 2	611	9.6	11.06	57	45	0.594	3.5	gravel	0.25	0.8	0
	Site 1	604	9.4	11.04	55	15	0.501	3.2	gravel	0.5	1.0	1.75
Unstocked	Site 3	621	9.7	12.46	53	84	0.569	2.3	gravel	0	0.3	0
	Site 2	586	9.7	11.32	45	3	0.662	2.3	silt	0	0.2	0
	Site 1	617	9.6	12.64	53	20	0.515	3.3	silt	0	0.2	0

* This is the sum of categorical scores for each of six types of cover; large substratum particles, tree roots, branches, in-stream vegetation, out-stream vegetation and deep water.

** This represents the dominant substratum particle size in each site.

*** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%.

**** This is the mean of categorical values assigned to each transect where 0=0%, 1=1-5%, 2=6-20%

***** This is the mean of categorical values assigned to each transect where 0=0%, 1=<1%, 2=1-10%, 3=11-20%, 4=>20% of water with depth greater than 10% of width

APPENDIX B.

FISH POPULATION STATISTICS

Figure B.1.Length frequency histograms for trout captured at six sites on the River Anton in December.

Figure B.2.Length frequency histograms for salmon parr captured at six sites on the River Anton in December.

Figure B.3.Length frequency histograms for grayling captured at six sites on the River Anton in December.

Figure B.4.Length frequency histograms for pike captured at six sites on the River Anton in December.

Figure B.5.Length frequency histograms for trout captured at six sites on the River Anton in January.

Figure B.6.Length frequency histograms for salmon parr captured at six sites on the River Anton in January.

Figure B.7.Length frequency histograms for grayling captured at six sites on the River Anton in January.

Figure B.8.Length frequency histograms for pike captured at six sites on the River Anton in January.

Figure B.9.Length frequency histograms for trout captured at six sites on the River Test in December.

Figure B.10.Length frequency histograms for salmon parr captured at six sites on the River Test in December.

Figure B.11.Length frequency histograms for grayling captured at six sites on the River Test in December.

Figure B.12.Map showing location of six sites electric fished on the River Anton in December, with graphical representation of fish densities (no. ha^{-1}) at each site, where S=salmon parr, T=trout, G=grayling and Pi=pike.

Figure B.13.Map showing location of six sites electric fished on the River Anton in January, with graphical representation of fish densities (no. ha^{-1}) at each site, where S=salmon parr, T=trout, G=grayling and Pi=pike.

Figure B.14.Map showing location of six sites electric fished on the River Test in December, with graphical representation of fish densities (no. ha^{-1}) at each site, where S=salmon parr, T=trout, G=grayling and Pi=pike.

Table B.1.Length weigth relationships for salmon parr, trout and grayling caught at six sites on each of the River Anton and River Test. Constants fit the equation $Log_e W = a + b Log_e L$.

Species	a	b	R^2(%)
Salmon parr	- 4.6	3.06	97.6
Trout	- 4.3	2.96	99.3
Grayling	- 5.4	3.32	98.7

Table B.2.The age of brown trout captured at six sites on each of the River Anton and River Test at different lengths.

Length (cm)	Age			
	0+	1+	2+	3+
12 - 13.9	1			
14 - 15.9	5			
16 - 17.9	3	1		
18 - 19.9		4		
20 - 21.9		4		
22 - 23.9		9	7	
24 - 25.9		6	6	2
26 - 27.9			4	2
28 - 29.9			7	2
30 - 31.9			3	1
32 - 33.9			1	
34 - 35.9			1	
36 - 37.9			1	1
38 - 39.9				
40 - 41.9				2
42 - 43.9				1
44 - 45.9				
46 - 47.9				1

48 - 49.9				

APPENDIX C.

PIT TAGGED SALMON PARR RECOVERED

Table C.1. Individual lengths, weights and PIT tag numbers of salmon parr captured at six sites in each of the River Anton and River Test.

PIT Tagged Salmon					
Site	Date	Length	Weight	PIT Tag Number	Adipose Clip
R. Anton Site 1 Stocked	18/12/95	11.3	17	41375A4069	
		8.7	7	4138122651	
		12.5	23	41380F2A2E	
		9.8	11	4138100759	
		9.4	10	413819460F	
		11.5	17	4138A4A4C	
		11	17	413808260D	
R.Anton Site 2 Stocked	18/12/95	11	17	4138241977	
		10.9	13	4138030004	
		13	28	4138293670	
R.Anton Site 3 Unstocked	19/12/95	11.8	22	4138020D6F	
R.Anton Site 1 Stocked	8/1/96	18.1	72		
R.Anton Site 2 Stocked	8/1/96	13.3	25	41382B6A4C	
		13.3	25		YES
R.Anton Site 1 Unstocked	12/1/96	10.4		413816300D	
		11.2			YES
R.Anton Site 3 Unstocked	12/1/96	12.7			
		12.1		41375A784D	

		13.9		4138096808	
R.Test Site 2 Stocked	19/12/95	9.4	11	4138121967	
R.Test Site 1 Unstocked	19/12/95	12.7	26	4138306076	
		10	11	4138215A01	

Table C.2. Individual lengths of trout and pike which contained PIT tagged salmon parr captured six sites on each of the River Anton and River Test. PIT tag numbers are recorded.

PIT Tags found inside Trout and Pike.				
Site	Date	Length cm	no. of PIT tags	PIT tag no.
TROUT				
R.Anton Site 1 stocked	18/12/95	27.9	1	4138163623
		28.1	1	4138114155
		33.5	1	41375C0E0C
		34.3	1	4137734864
		39.2	1	41381B203C
R.Anton Site 2 stocked	18/12/95	31.6	1	4138227D7C
		33.4	1	4138104C3E
		44.4	1	41381A986E
R.Anton Site 3 unstocked	19/12/95	33.0	1	413826000B
		34.2	1	4138231A1F
		43.3	1	413820CB31
R.Anton Site 3 stocked	8/1/96	35	1	41380ALA4C
R.Test Site 1 stocked	19/12/95	32.5	2	4138255B2E 4138233E06
R.Test Site 3 stocked	19/12/95	33.0	1	41382A121A
PIKE				
R.Anton Site 2 stocked	18/12/95	43.8	1	4138294B0B
R.Anton Site 1 stocked	8/1/96	36.2	1	413808743E

APPENDIX D.

SITE PHOTOGRAPHS AND RAW DATA

Figure D.1.Photograph of River Anton, unstocked reach, site 1.

Table D.1.Summary table of fish catches in River Anton, unstocked reach, site 1

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	0	n/a	n/a
	January	1	1	0
Trout	December	15	n/a	n/a
	January	11	0	0
Grayling	December	17	n/a	n/a
	January	37	13	6
Pike	December	0	n/a	n/a
	January	0	0	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.2.Photograph of River Anton, unstocked reach, site 2.

Table D.2.Summary table of fish catches in River Anton, unstocked reach, site 2.

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	0	n/a	n/a
	January	0	0	0
Trout	December	25	n/a	n/a
	January	33	7	0
Grayling	December	30	n/a	n/a
	January	27	10	7
Pike	December	0	n/a	n/a
	January	0	0	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.3.Photograph of River Anton, unstocked reach, site 3.

Table D.3.Summary table of fish catches in River Anton, unstocked reach, site 3.

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	1	n/a	n/a
	January	1	1	1
Trout	December	43	n/a	n/a
	January	46	5	3
Grayling	December	33	n/a	n/a
	January	39	13	4
Pike	December	3	n/a	n/a
	January	0	0	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.4.Photograph of River Anton, stocked reach, site 1.

Table D.4.Summary table of fish catches in River Anton, stocked reach, site 1

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	7	n/a	n/a
	January	0	1	0
Trout	December	18	n/a	n/a
	January	30	6	2
Grayling	December	13	n/a	n/a
	January	24	2	2
Pike	December	0	n/a	n/a
	January	0	1	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.5.Photograph of River Anton, stocked reach, site 2.

Table D.5.Summary table of fish catches in River Anton, stocked reach, site 2.

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	3	n/a	n/a
	January	1	0	1
Trout	December	45	n/a	n/a
	January	34	4	0
Grayling	December	17	n/a	n/a
	January	19	6	1
Pike	December	1	n/a	n/a
	January	1	0	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.6.Photograph of River Anton, stocked reach, site 3.

Table D.6.Summary table of fish catches in River Anton, stocked reach, site 3.

Species	Month	Shock 1	Shock 2	Shock 3
Salmon parr	December	0	n/a	n/a
	January	0	0	0
Trout	December	10	n/a	n/a
	January	17	5	4
Grayling	December	9	n/a	n/a
	January	18	10	4
Pike	December	2	n/a	n/a
	January	2	0	0
Perch	December	0	n/a	n/a
	January	0	0	0

Figure D.7.Photograph of the River Test, unstocked reach, sites 1, 2 &3.

Table D.7.Summary table of fish catches in River Test, unstocked reach, sites 1, 2 & 3.

Species	Month	Shock 1	Shock 2	Shock3
Salmon parr	Site 1	2	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	0	n/a	n/a
Trout	Site 1	0	n/a	n/a
	Site 2	2	n/a	n/a
	Site 3	1	n/a	n/a
Grayling	Site 1	1	n/a	n/a
	Site 2	1	n/a	n/a
	Site 3	0	n/a	n/a
Pike	Site 1	0	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	0	n/a	n/a
Perch	Site 1	0	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	0	n/a	n/a

Figure D.8.Photograph of the River Test, unstocked reach, sites 1, 2 &3.

Table D.8.Summary table of fish catches in River Test, stocked reach, sites 1, 2 & 3.

Species	Month	Shock 1	Shock 2	Shock3
Salmon parr	Site 1	0	n/a	n/a
	Site 2	1	n/a	n/a
	Site 3	0	n/a	n/a
Trout	Site 1	1	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	2	n/a	n/a
Grayling	Site 1	7	n/a	n/a
	Site 2	1	n/a	n/a
	Site 3	2	n/a	n/a
Pike	Site 1	0	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	0	n/a	n/a
Perch	Site 1	0	n/a	n/a
	Site 2	0	n/a	n/a
	Site 3	0	n/a	n/a

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